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REGULATORY GUIDE 1.145

ATMOSPHERIC DISPERSION MODELS FOR POTENTIAL ACCIDENT CONSEQUENCE ASSESSMENTS AT NUCLEAR POWER PLANTS

A. INTRODUCTION

Section 100.10 of 10 CFR Part 100, "Reactor Site Criteria," states that meteorological conditions at the site and surrounding area should be considered in determining the acceptability of a site for a power reactor. Section 50.34 of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires that each applicant for a construction permit or operating license provide an analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from the operation of the facility. Section 50.34 of 10 CFR Part 50 also states that special attention should be directed to the site evaluation factors identified in 10 CFR Part 100 in the assessment of the site.

The regulatory positions presented in this guide represent a substantial change from procedures previously used to determine relative concentrations for assessing the potential offsite radiological consequences for a range of postulated accidental releases of radioactive material to the atmosphere. These procedures now include consideration of plume meander, directional dependence of dispersion conditions, and wind frequencies for various locations around actual exclusion area and low population zone (LPZ) boundaries.[1]

The direction-dependent approach provides an improved basis for relating the Part 100-related review of a proposed reactor to specific site considerations. Accordingly, this guide provides an acceptable methodology for determining site-specific relative concentrations (χ/Q) and should be used in determining χ/Q values for the evaluations discussed in Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," and Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors." A number of other regulatory guides also include recommendations for or references to radiological analyses of potential accidents. The applicability of the specific criteria discussed herein to these other analyses will be considered on a case-by-case basis. Until such time as generic guidelines are developed for such analyses, the methodology provided in this guide is acceptable to the NRC staff.

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The Advisory Committee on Reactor Safeguards has[*] been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

The atmospheric diffusion[2] models described in this guide reflect review of recent experimental data on diffusion from releases at ground level at open sites and from releases at various locations on reactor facility buildings during stable atmospheric conditions with low windspeeds (Refs. 1 through 6). These tests confirm the existence of effluent plume "meander" during low windspeed conditions and neutral (D) and stable (E, F, and G) atmospheric stability conditions (as defined by the temperature difference (ΔT) criteria in Regulatory Guide 1.23, "Onsite Meteorological Programs," and provide bases for quantifying the effects of plume meander on effluent concentrations. Effluent concentrations measured over a period of 1 hour under such conditions have been shown to be substantially lower than would be predicted using the traditional curves (Ref. 7) of lateral and vertical plume spread.

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[1] For additional information concerning the bases for the regulatory positions presented in this guide, see NUREG/CR-2260, "Technical Basis for Regulatory Guide 1.145."

[*] Lines indicate substantive changes from previous issue.

[2] In discussions throughout this regulatory guide, *atmospheric dispersion* will be considered as consisting of two components: *atmospheric transport* due to organized or mean airflow within the atmosphere and *atmospheric diffusion* due to disorganized or random air motions. Plume depletion and surface deposition of airborne materials are not included in the dispersion models described in this guide.

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The procedures in this guide also recognize that atmospheric dispersion conditions and wind frequencies are usually directionally dependent; that is, certain airflow directions can exhibit substantially more or less favorable diffusion conditions than others, and the wind can transport effluents in certain directions more frequently than in others. The procedures also allow evaluations of atmospheric dispersion for directionally variable distances such as a noncircular exclusion area boundary.

C. REGULATORY POSITION

This section identifies acceptable methods for (1) calculating atmospheric relative concentration (χ/Q) values, (2) determining χ/Q values on a directional basis, (3) determining χ/Q values on an overall site basis, and (4) choosing χ/Q values to be used in evaluations of the types of events described in Regulatory Guides 1.3 and 1.4.

Selection of conservative, less detailed site parameters for the evaluation may be sufficient to establish compliance with regulatory guidelines.

1. CALCULATION OF ATMOSPHERIC RELATIVE CONCENTRATION (χ/Q) VALUES

Equations and parameters presented in this section should be used unless unusual siting, meteorological, or terrain conditions dictate the use of other models or considerations. Site-specific atmospheric diffusion tests covering a full range of conditions may be used as a basis for modifying the equations and parameters.

1.1 Meteorological Data Input

The meteorological data needed for χ/Q calculations include windspeed, wind direction, and a measure of atmospheric stability. These data should represent hourly averages as defined in Regulatory Guide 1.23.

Wind direction should be classed into 16 compass directions (22.5-degree sectors centered on true north, north-northeast, etc.).

Atmospheric stability should be determined by vertical ΔT between the release height and the 10-meter level. Acceptable stability classes are given in Regulatory Guide 1.23. If other well-documented parameters are used to determine plume dispersion (with appropriate justification), the models described in this guide may require modification. A well-documented parameter is one that is substantiated by diffusion data collected in terrain conditions similar to those at the nuclear power plant site being considered.

Calms should be defined as hourly average windspeeds below the vane or anemometer starting speed, whichever is higher (to reflect limitations in instrumentation). If the instrumentation program conforms to the regulatory position in Regulatory Guide 1.23, calms should be assigned a windspeed equal to the vane or anemometer starting speed, whichever is higher. Otherwise, consideration of a conservative evaluation of calms, taking into account the limitations of the windspeed measurement system, will be necessary. Wind directions during calm conditions should be assigned in proportion to the directional distribution of noncalm winds with speeds less than 1.5 meters per second.[3]

1.2 Determination of Distances for χ/Q Calculations

For each wind direction sector, χ/Q values for each significant release point should be calculated at an appropriate exclusion area boundary distance and outer low population zone (LPZ) boundary distance. The following procedure should be used to determine these distances. The procedure takes into consideration the possibility of curved airflow trajectories, plume segmentation (particularly in low wind, stable conditions), and the potential for windspeed and wind direction frequency shifts from year to year.

For each of the 16 sectors, the distance for exclusion area boundary or outer LPZ boundary χ/Q calculation should be the minimum distance from the stack or, in the case of releases through vents or building penetrations, the nearest point on the building to the exclusion area boundary or outer LPZ boundary within a 45-degree sector centered on the compass direction of interest.

For stack releases, the maximum ground-level concentration in a sector may occur beyond the exclusion area boundary distance or outer LPZ boundary distance. Therefore, for stack releases, χ/Q calculations should be made in each sector at each minimum boundary distance and at various distances beyond the exclusion area boundary distance to determine the maximum relative concentration for consideration in subsequent calculations.

1.3 Calculation of χ/Q Values at Exclusion Area Boundary Distances

Relative concentrations that can be assumed to apply at the exclusion area boundary for 2 hours immediately following an accident should be determined.[4] Calculations based on meteorological data representing a 1-hour average should be assumed to apply for the entire 2-hour period. This assumption is reasonably conservative considering the small variation of χ/Q values with averaging time (Ref. 8). If releases associated with a postulated event are estimated to occur in a period of less than 20 minutes, the applicability of these models should be evaluated on a case-by-case basis.

Procedures for calculating "2-hour" χ/Q values depend on the mode of release. The procedures are described below.

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[3] Staff experience has shown that noncalm windspeeds below 1.5 meters per second provide a reasonable range for defining the distribution of wind direction during light winds.

[4] See § 100.11 of 10 CFR Part 100.

1.3.1 Releases Through Vents or Other Building Penetrations

This class of release modes includes all release points or areas that are effectively lower than two and one-half times the height of adjacent solid structures (Ref. 9). Within this class, two sets of meteorological conditions are treated differently, as follows:

a. During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the windspeed at the 10-meter level is less than 6 meters per second, horizontal plume meander may be considered. χ/Q values may be determined through selective use of the following set of equations for ground-level relative concentrations at the plume centerline:

$$\chi/Q = \frac{1}{\bar{U}_{10}(\pi\sigma_y\sigma_z + A/2)} \tag{1}$$

$$\chi/Q = \frac{1}{\bar{U}_{10}(3\pi\sigma_y\sigma_z)} \tag{2}$$

$$\chi/Q = \frac{1}{\bar{U}_{10}\pi\Sigma_y\sigma_z} \tag{3}$$

where

χ/Q is relative concentration, in sec/m^3,

π is 3.14159,

$\bar{U}_{10}$ is windspeed at 10 meters above plant grade,[5] in m/sec,

σ_y is lateral plume spread, in m, a function of atmospheric stability and distance (see Fig. 1),

σ_z is vertical plume spread, in m, a function of atmospheric stability and distance (see Fig. 2),

Σ_y is lateral plume spread with meander and building wake effects, in m, a function of atmospheric stability, windspeed $\bar{U}_{10}$, and distance [for distances of 800 meters or less, $\Sigma_y = M\sigma_y$, where M is determined from Fig. 3; for distances greater than 800 meters, $\Sigma_y = (M - 1)\,\sigma_{y800m} + \sigma_y$], and

A is the smallest vertical-plane cross-sectional area of the reactor building, in m^2. (Other structures or a directional consideration may be justified when appropriate.)

χ/Q values should be calculated using Equations 1, 2, and 3. The values from Equations 1 and 2 should be compared and the higher value selected. This value should be compared with the value from Equation 3, and the lower value of these two should then be selected as the appropriate χ/Q value. Examples and a detailed explanation of the rationale for determining the controlling conditions are given in Appendix A to this guide.

b. During all other meteorological conditions, plume meander should not be considered. The appropriate χ/Q value for these conditions is the higher value calculated from Equation 1 or 2.

1.3.2 Stack Releases

This class of release modes includes all release points at levels that are two and one-half times the height of adjacent solid structures or higher (Ref. 9). Nonfumigation conditions are treated separately.

a. For nonfumigation conditions, the equation for ground-level relative concentration at the plume centerline for stack releases is:

$$\chi/Q = \frac{1}{\pi\bar{U}_h\sigma_y\sigma_z}\exp\left[\frac{-h_e^{\,2}}{2\sigma_z^{\,2}}\right] \tag{4}$$

where

$\bar{U}_h$ is windspeed representing conditions at the release height, in m/sec,

h_e is effective stack height, in m: $h_e = h_s - h_t$,

h_s is the initial height of the plume (usually the stack height) above plant grade, in m, and

h_t is the maximum terrain height above plant grade between the release point and the point for which the calculation is made, in m. If h_t is greater than h_s, then $h_e = 0$.

For those cases in which the applicant can demonstrate that the vertical velocity of effluent plumes from the plant (because of either buoyancy or mechanical jet effects) will be maintained during the course of the accident, this additional velocity may be considered in the determination of the effective stack height (h_e) using the same procedures described in regulatory position 2.a of Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors."

b. For fumigation conditions, a "fumigation χ/Q" should be calculated for each sector as follows. The equation for ground-level relative concentration at the plume centerline for stack releases during fumigation conditions is:

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[5] **The 10-meter level is considered to be representative of the layer through which the plume is mixed when subjected to building wake effects.**

$$\chi/Q = \frac{1}{(2\pi)^{1/2}\,\bar{U}_{h_e}\,\sigma_y h_e},\ h_e > 0 \qquad (5)$$

where

$\bar{U}_{h_e}$ is windspeed representative of the fumigation layer of depth h_e, in m/sec; in lieu of information to the contrary, the NRC staff considers a value of 2 meters per second as a reasonably conservative assumption for h_e of about 100 meters, and

σ_y is the lateral plume spread, in m, that is representative of the layer at a given distance; a moderately stable (F) atmospheric stability condition is usually assumed.

Equation 5 cannot be applied indiscriminately because the χ/Q values calculated, using this equation, become unrealistically large as h_e becomes small (on the order of 10 meters). The χ/Q values calculated using Equation 5 must therefore be limited by certain physical restrictions. The highest ground-level χ/Q values from elevated releases are expected to occur during stable conditions with low windspeeds when the effluent plume impacts on a terrain obstruction (i.e., $h_e = 0$). However, elevated plumes diffuse upward through the stable layer aloft as well as downward through the fumigation layer. Thus ground-level relative concentrations for elevated releases under fumigation conditions cannot be higher than those produced by nonfumigation, stable atmospheric conditions with $h_e = 0$. For the fumigation case that assumes F stability and a windspeed of 2 meters per second, Equation 4 should be used instead of Equation 5 at distances greater than the distance at which the χ/Q values determined using Equation 4 with $h_e = 0$ and Equation 5 are equal.

1.4 Calculation of χ/Q Values at Outer LPZ Boundary Distances

Two-hour χ/Q values should also be calculated at outer LPZ boundary distances. The procedures described above for exclusion area boundary distances (see regulatory position 1.3) should be used.

An annual average (8760-hour) χ/Q should be calculated for each sector at the outer LPZ boundary distance for that sector, using the method described in regulatory position 1.c of Regulatory Guide 1.111. For stack releases, h_e should be determined as described in regulatory position 1.3.2 above.

These calculated 2-hour and annual average values are used in regulatory position 2.2 to determine sector χ/Q values at outer LPZ boundary distances for various intermediate time periods.[6]

2. DETERMINATION OF MAXIMUM SECTOR χ/Q VALUES

The χ/Q values calculated in regulatory position 1 are used to determine "sector χ/Q values" and "maximum sector χ/Q values" for the exclusion area boundary and the outer LPZ boundary.

2.1 Exclusion Area Boundary

2.1.1 General Method

Using the χ/Q values calculated for each hour of data according to regulatory position 1.3, a cumulative probability distribution of χ/Q values should be constructed for each of the 16 sectors. Each distribution should be described in terms of probabilities of given χ/Q values being exceeded in that sector during the total time. A plot of χ/Q versus probability of being exceeded should be made for each sector, and a smooth curve should be drawn to form an upper bound of the computed points. For each of the 16 curves, the χ/Q value that is exceeded 0.5 percent[7] of the total number of hours in the data set should be selected (Ref. 10). These are the sector χ/Q values. The highest of the 16 sector values is defined as the maximum sector χ/Q value.

2.1.2 Fumigation Conditions for Stack Releases

Regulatory position 1.3.2 describes procedures for calculating a fumigation χ/Q for each sector. These sector fumigation values, and the general (nonfumigation) sector values obtained in regulatory position 2.1.1, are used to determine appropriate sector fumigation χ/Qs. Conservative assumptions for fumigation conditions, which differ for inland and coastal sites, are described below. Modifications may be appropriate for specific sites.

a. Inland Sites: For stack releases at sites located 3.2 kilometers or more from large bodies of water (e.g., oceans or Great Lakes), a fumigation condition should be assumed to exist at the time of the accident and continue for 1/2 hour (Ref. 11). For each sector, if the sector fumigation χ/Q exceeds the sector nonfumigation χ/Q, use the fumigation value for the 0 to 1/2-hour time period and the nonfumigation value for the 1/2-hour to 2-hour time period. Otherwise, use the nonfumigation sector value for the entire 0 to 2-hour time period. The 16 (sets of) values thus determined should be used in dose assessments requiring time-integrated concentration considerations.

b. Coastal Sites: For stack releases at sites located less than 3.2 kilometers from large bodies of water, a fumigation condition should be assumed to exist at the exclusion area boundary at the time of the accident and continue for the entire 2-hour period. For each sector, the larger of the sector fumigation χ/Q and the sector nonfumigation χ/Q should be used for the 2-hour period. Of these 16 sector values, the highest is the maximum sector χ/Q value.

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[6] See § 100.11 of 10 CFR Part 100.

[7] Selection of the 0.5 percent level is based on an equality, without consideration of plume meander, between the 5 percent directionally independent evaluation of χ/Q (the previous evaluation procedure) and the 0.5 percent directionally dependent evaluation of χ/Q averaged over a reasonably representative number of existing nuclear power plant sites. See NUREG/CR-2260 for additional information.

c. Modifications: These conservative assumptions do not consider frequency and duration of fumigation conditions as a function of airflow direction. If information can be presented to substantiate the likely directional occurrence and duration of fumigation conditions at a site, the assumptions of fumigation in all directions and of duration of 1/2 hour and 2 hours for the exclusion area boundary may be modified. Then fumigation need only be considered for airflow directions in which fumigation has been determined to occur and of a duration determined from the study of site conditions.[8]

2.2 Outer LPZ Boundary

2.2.1 General Method

Sector χ/Q values for the outer LPZ boundary should be determined for various time periods throughout the course of the postulated accident.[9] The time periods should represent appropriate meteorological regimes, e.g., 8 and 16 hours and 3 and 26 days as presented in Section 2.3.4 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants–LWR Edition," or other time periods appropriate to release durations.

For a given sector, the average χ/Q values for the various time periods may be approximated by a logarithmic interpolation between the 2-hour[10] sector χ/Q and the annual average (8760-hour) χ/Q for the same sector. The 2-hour sector χ/Q for the outer LPZ boundary is determined using the general method given for the exclusion area boundary in regulatory position 2.1. The annual average χ/Q for a given sector is determined as described in regulatory position 1.4.

The logarithmic interpolation procedure produces results that are consistent with studies of variations of average concentrations with time periods up to 100 hours (Ref. 8). Alternative methods should also be consistent with these studies and should produce results that provide a monotonic decrease in average χ/Q with time.

For each time period, the highest of the 16 sector χ/Q values should be identified. In most cases, these highest values will occur in the same sector for all time periods. These are then the maximum sector χ/Q values. However, if the highest sector χ/Qs do not all occur in the same sector, the 16 (sets of) values will be used in dose assessments requiring time-integrated concentration considerations. The set of χ/Q values resulting in the highest time-integrated dose within a sector should be considered the maximum sector χ/Q values.

2.2.2 Fumigation Conditions for Stack Releases

Determination of sector χ/Q values for fumigation conditions at the outer LPZ boundary involves the following assumptions concerning the duration of fumigation for inland and coastal sites:

a. Inland Sites: For stack releases at sites located 3.2 kilometers or more from large bodies of water, a fumigation condition should be assumed to exist at the outer LPZ boundary at the time of the accident and continue for 1/2 hour. Sector χ/Q values for fumigation should be determined as for the exclusion area boundary in regulatory position 2.1.2.

b. Coastal Sites: For stack releases at sites located less than 3.2 kilometers from large bodies of water, a fumigation condition should be assumed to exist at the outer LPZ boundary following the arrival of the plume and continue for a 4-hour period (Ref. 11). Sector χ/Q values for fumigation should be determined as for the exclusion area boundary in regulatory position 2.1.2.

c. The modifications discussed in regulatory position 2.1.2 may also be considered for the outer LPZ boundary.

3. DETERMINATION OF 5 PERCENT OVERALL SITE χ/Q VALUE

The χ/Q values that are exceeded no more than 5 percent of the total number of hours in the data set around the exclusion area boundary and around the outer LPZ boundary should be determined as follows (Ref. 10):

Using the χ/Q values calculated according to regulatory position 1, an overall cumulative probability distribution for all directions combined should be constructed. A plot of χ/Q versus probability of being exceeded should be made, and an upper bound curve should be drawn. The 2-hour χ/Q value that is exceeded 5 percent of the time should be selected from this curve as representing the dispersion condition indicative of the type of release being considered. In addition, for the outer LPZ boundary the maximum of the 16 annual average χ/Q values should be used along with the 5 percent 2-hour χ/Q value to determine χ/Q values for the intermediate time periods by logarithmic interpolation.

4. SELECTION OF χ/Q VALUES TO BE USED IN EVALUATIONS

The χ/Q value for exclusion area boundary or outer LPZ boundary evaluations should be the maximum sector χ/Q

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[8] For example, examination of site-specific information at a location in a pronounced river valley may indicate that fumigation conditions occur only during the downvalley "drainage flow" regime and persist for durations of about 1/2 hour. Therefore, in this case, airflow directions other than the downvalley directions may be excluded from consideration of fumigation conditions, and the duration of fumigation would still be considered as 1/2 hour. On the other hand, data from sites in open terrain (noncoastal) may indicate no directional preference for fumigation conditions but may indicate durations much less than 1/2 hour. In this case, fumigation should be considered for all directions, but with durations of less than 1/2 hour.

[9] See § 100.11 of 10 CFR Part 100.

[10] The χ/Qs are based on 1-hour averaged data but are assumed to apply for 2 hours.

(regulatory position 2) or the 5 percent overall site χ/Q (regulatory position 3), whichever is higher. All direction-dependent sector values should be presented for consideration of the appropriateness of the exclusion area and outer LPZ boundaries. Where the basic meteorological data necessary for the analyses described herein substantially deviate from the regulatory position stated in Regulatory Guide 1.23, consideration should be given to the resulting uncertainties in dispersion estimates.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff plans for using this regulatory guide.

Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of the following:

1. For early site review applications.
2. For construction permit applications (including those incorporating or referencing a duplicate plant design and those submitted under the replicate plant option of the Commission's standardization program).
3. Operating license applications.

For operating reactors, the licensee may use the method described in this guide or may continue to use the method previously contained or referenced in the FSAR for such facilities.

This guide does not apply to the following options specified in the Commission's standardization policy under the reference system concept:

1. Preliminary design approval applications.
2. Final design approval, Type 1, applications.
3. Final design approval, Type 2, applications.
4. Manufacturing license applications.

The implementation date for this guide is December 30, 1982.

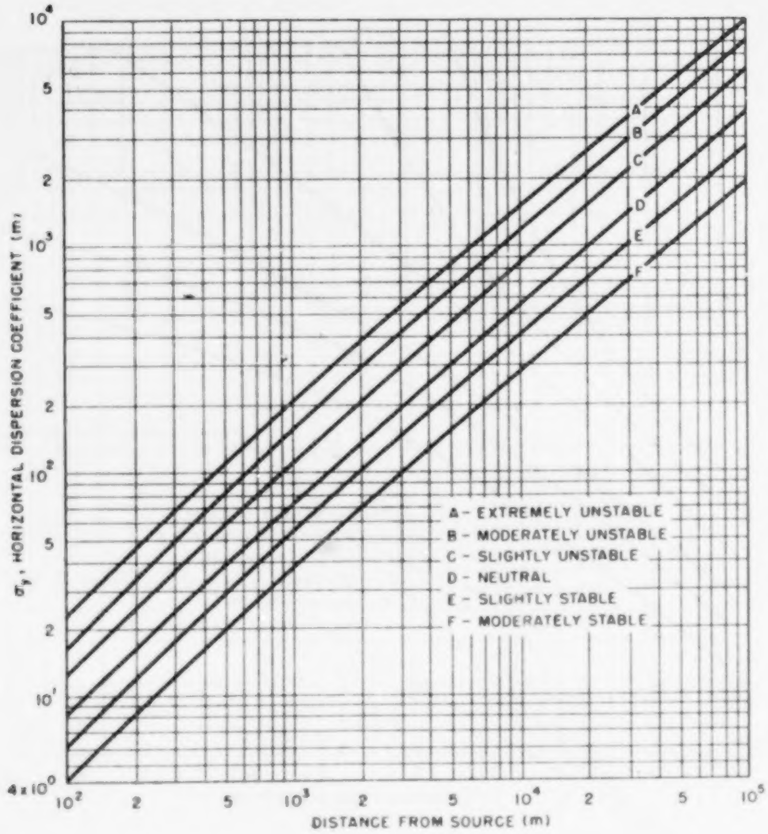

Figure 1. Lateral diffusion without meander and building wake effects, σ_y, vs. downwind distance from source for Pasquill's turbulence types (atmospheric stability) (Ref. 7).

The sigma values presented above are for unrestricted flow over relatively flat, uniform terrain. They may require modification before application in situations in which rough terrain or restricted flow conditions (e.g., within the confines of a narrow valley) must be considered or in coastal and desert areas. (See Ref. 12 for additional information.)

For purposes of estimating σ_y during extremely stable (G) atmospheric stability conditions, without plume meander or other lateral enhancement, the following approximation is appropriate:

$$\sigma_y(G) = \frac{2}{3}\sigma_y(F)$$

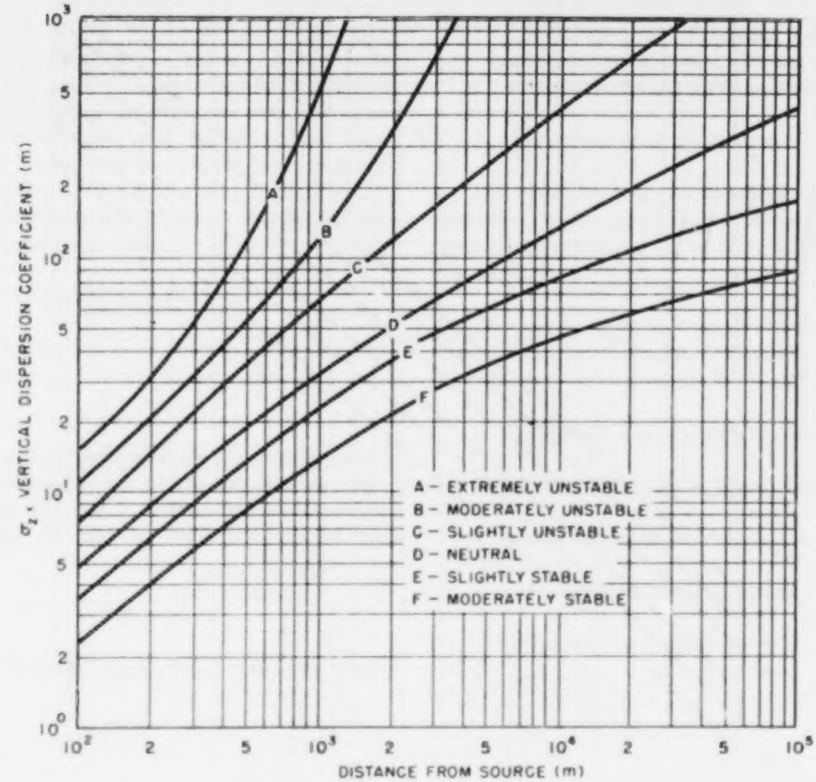

Figure 2. Vertical diffusion without meander and building wake effects, σ_z, vs. downwind distance from source for Pasquill's turbulence types (atmospheric stability) (Ref. 7).

The sigma values presented above are for unrestricted flow over relatively flat, uniform terrain. They may require modification before application in situations in which rough terrain or restricted flow conditions (e.g., within the confines of a narrow valley) must be considered or in coastal and desert areas. (See Ref. 12 for additional information.)

For purposes of estimating σ_z during extremely stable (G) atmospheric stability conditions, the following approximation is appropriate:

$$\sigma_z(G) = \frac{3}{5}\sigma_z(F)$$

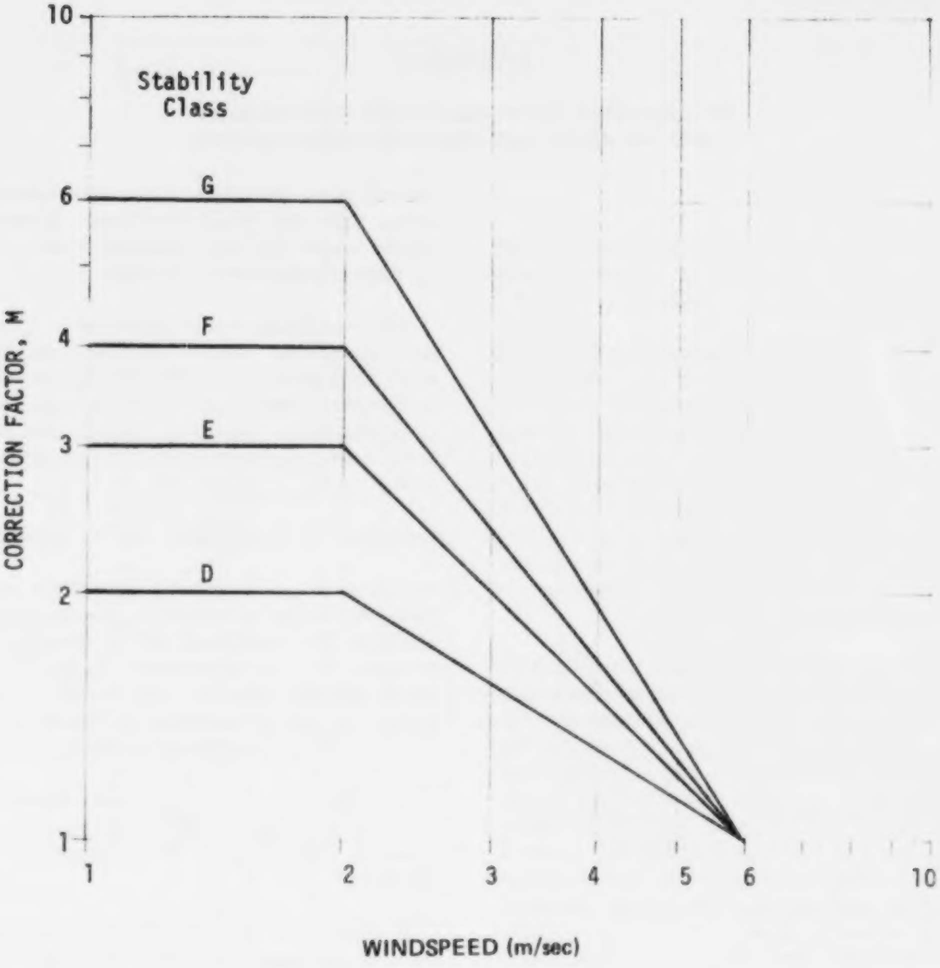

Figure 3. Correction factors for σ_y values by atmospheric stability class (see Appendix A to this guide).

APPENDIX A

ATMOSPHERIC DIFFUSION MODEL FOR RELEASE THROUGH VENTS AND BUILDING PENETRATIONS

Rationale

The effects of building wake mixing and ambient plume meander on atmospheric dispersion are expressed in this guide in terms of conditional use of Equations 1, 2, and 3.[1]

Equations 1 and 2 are formulations that have been acceptable for evaluating nuclear power plant sites over a period of many years (Ref. 7 and Regulatory Guides 1.3 and 1.4). The conditional use of Equations 1 and 2 provides an assessment of atmospheric diffusion, including only the effects of building wake mixing that occur during moderate windspeed conditions (>3 m/sec). These equations have recently been found to provide estimates of ground-level concentrations that are consistently too high during light wind and stable or neutral atmospheric conditions for 1-hour release durations (Refs. 1 through 6).

Equation 3 is an empirical formulation based on NRC staff analysis of atmospheric diffusion experiment results (Ref. 2). The NRC staff examined values of lateral plume spread with meander and building wake effects (Σ_y) by atmospheric stability class (based on ΔT), calculated from measured ground-level concentrations from the experimental results. Plots of the computed Σ_y values by atmospheric stability class and downwind distance were analyzed conservatively but within the scatter of the data points by virtually enveloping most test data. The resultant analysis is the basis for the correction factors applied to the σ_y values (see Fig. 3 of this guide). Thus, Equation 3 identifies conservatively the combined effects of increased plume meander and building wake on diffusion in the horizontal crosswind direction under light wind and stable or neutral atmospheric conditions, as quantified in Figure 3. These experiments also indicate that vertical building wake mixing during light wind and stable conditions is not as complete as during moderate wind, unstable conditions. In addition, vertical plume meander is shown to be virtually nonexistent during light wind, stable conditions. However, the experimental results for both situations could not be quantified for general application at this time.

The conditional use of Equations 1, 2, and 3 is considered appropriate because (1) horizontal plume meander tends to dominate dispersion during light wind and stable or neutral conditions and (2) building wake mixing becomes more effective in dispersing effluents than meander effects as the windspeed increases and the atmosphere becomes less stable.

Examples of Conditional Use of Diffusion Equations

Figures A-1, A-2, and A-3 show plots of $\chi\bar{U}_{10}/Q$ (χ/Q multiplied by the windspeed $\bar{U}_{10}$) versus downwind distance based on the conditional use (as described in regulatory position 1.3.1) of Equations 1, 2, and 3 during atmospheric stability class G. The variable M for Equation 3 equals 6, 3, and 2 respectively in Figures A-1, A-2, and A-3 (M is as defined in regulatory position 1.3.1).

In Figure A-1, the $\chi\bar{U}_{10}/Q$ from Equation 3 ($M = 6$) is less than the higher value from Equation 1 or 2 at all distances. Therefore, for $M = 6$, Equation 3 is used for all distances.

In Figure A-2, the $\chi\bar{U}_{10}/Q$ from Equation 3 ($M = 3$) is less than the higher value from Equation 1 or 2 beyond 0.8 km. Therefore, for $M = 3$, Equation 3 is used beyond 0.8 km. For distances less than 0.8 km, the value from Equation 3 equals that from Equation 2. Equation 2 is therefore used for distances less than 0.8 km.

In Figure A-3, the $\chi\bar{U}_{10}/Q$ from Equation 3 ($M = 2$) is never less than the higher value from Equation 1 or 2. Therefore, for $M = 2$, Equation 3 is not used at all. Instead, Equation 2 is used up to 0.8 km, and Equation 1 is used beyond 0.8 km.

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[1] For additional information see NUREG/CR-2260.

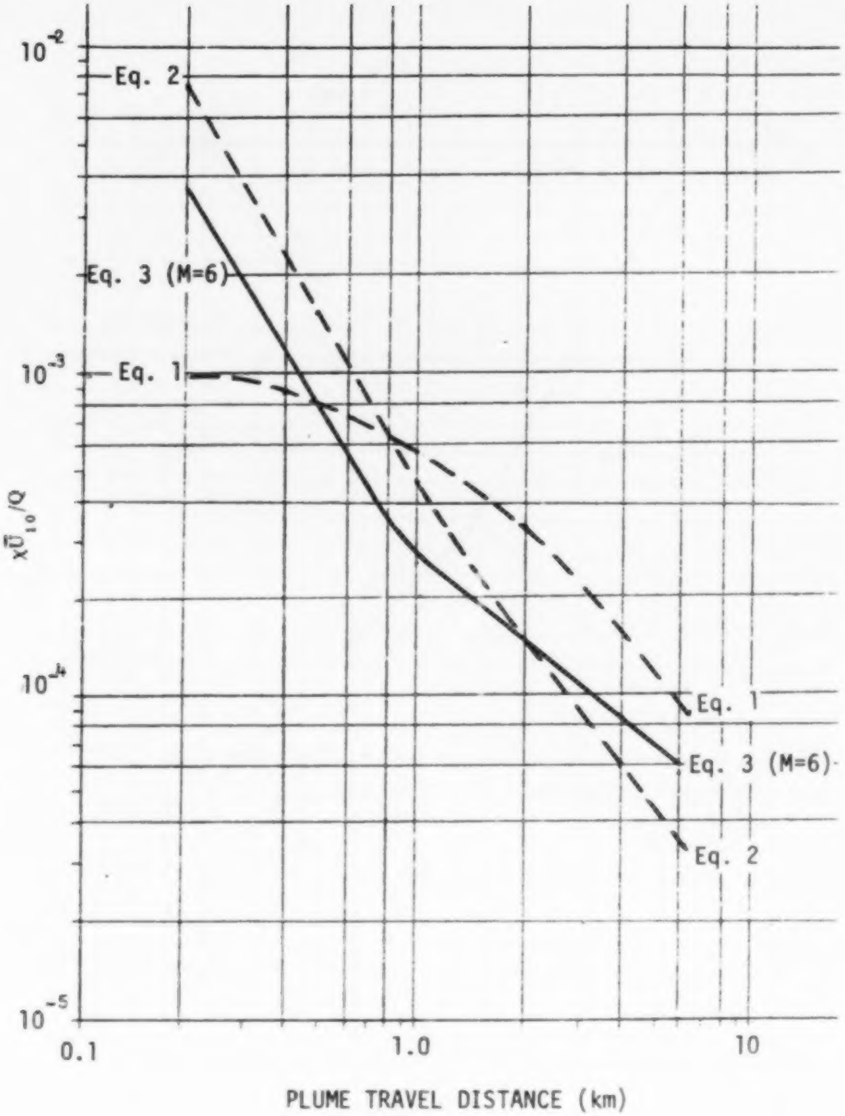

Figure A-1. $\chi\bar{U}_{10}/Q$ as a function of plume travel distance for G stability condition using Equations 1, 2, and 3 (M = 6).

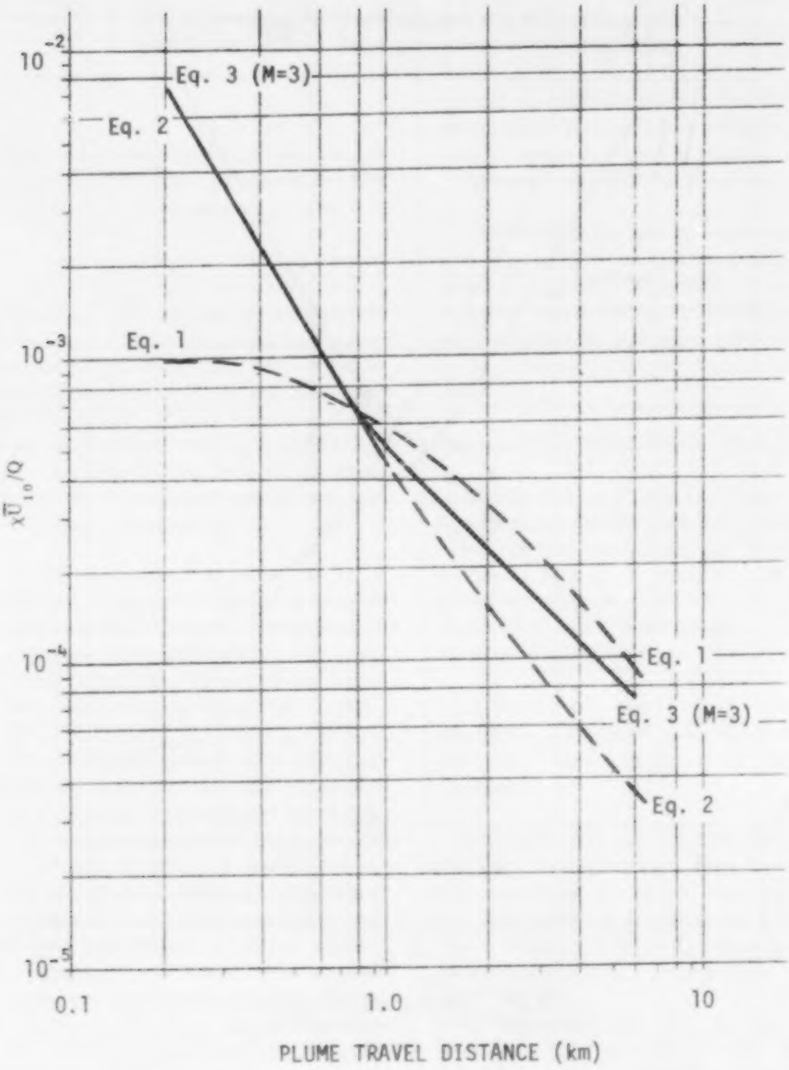

Figure A-2. $\chi\bar{U}_{10}/Q$ as a function of plume travel distance for G stability condition using Equations 1, 2, and 3 (M = 3).

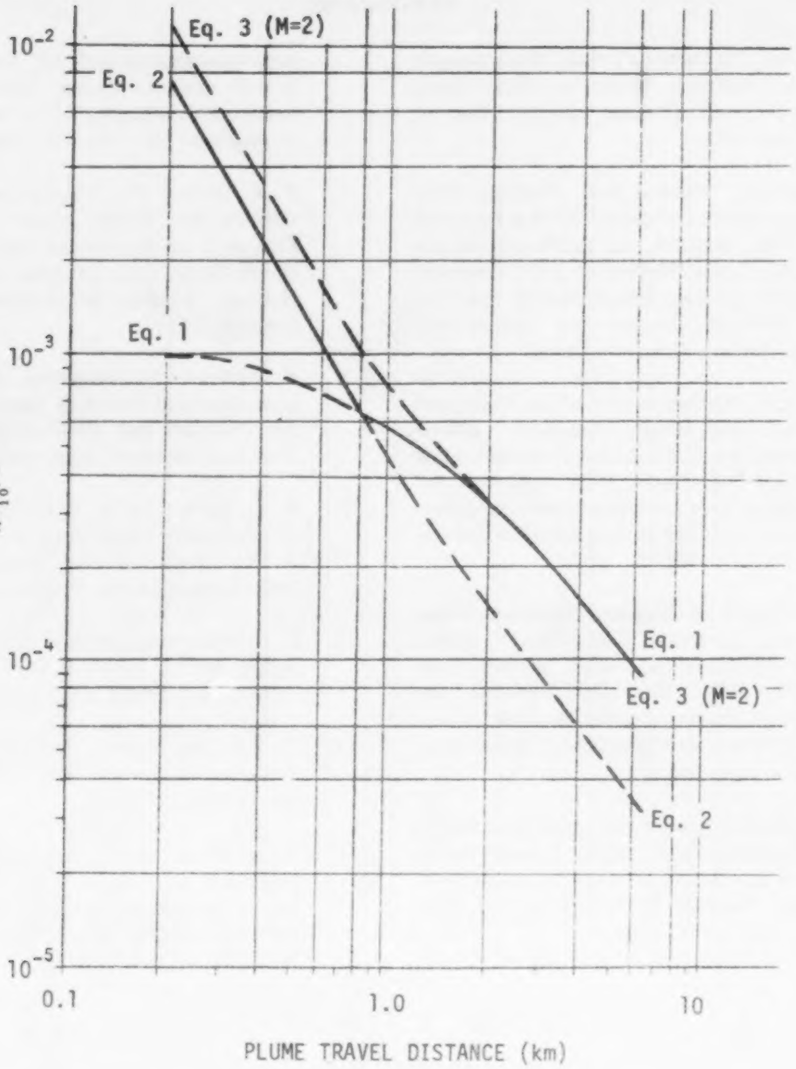

Figure A-3. $\chi\bar{U}_{10}/Q$ as a function of plume travel distance for G stability condition using Equations 1, 2, and 3 (M = 2).

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6-2/3.1/rev. 1

Revision 1
January 1982

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

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REGULATORY GUIDE 3.1
(Task FP 027-5)

USE OF BOROSILICATE-GLASS RASCHIG RINGS AS A NEUTRON ABSORBER IN SOLUTIONS OF FISSILE MATERIAL

A. INTRODUCTION

Section 70.22, "Contents of Applications," of 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," requires that applications for a specific license to own, acquire, deliver, receive, possess, use, or transfer special nuclear material contain proposed procedures to avoid accidental conditions of criticality. Procedures for this purpose include incorporating neutron-absorbing material such as boron in process equipment. This regulatory guide provides guidance for complying with this portion of the Commission's regulations by describing procedures acceptable to the NRC staff for the prevention of criticality accidents by use of borosilicate-glass raschig rings as a neutron absorber in solutions of fissile material.

B. DISCUSSION

[*] ANSI/ANS 8.5-1979, "Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material,"[1] is a revision of ANSI N16.4-1971 and was prepared by Subcommittee 8, Fissionable Materials Outside Reactors, of the Standards Committee of the American Nuclear Society. ANSI/ANS 8.5-1979 was approved by the American National Standards Committee N16, Nuclear Criticality Safety, in early 1979 and by the American National Standards Institute (ANSI) on October 9, 1979.

ANSI/ANS 8.5-1979 provides guidance on the use of borosilicate-glass raschig rings as a neutron absorber in solutions of fissile material. The standard applies to the use of borosilicate-glass raschig rings for primary and for secondary criticality control in solutions containing ^{235}U, ^{239}Pu, and ^{233}U. The chemical and physical environment, properties of the rings and packed vessels, maintenance inspection procedures, and criticality operating limits are specified in the standard.

Maximum permissible concentrations of homogeneous solutions of plutonium or of uranium in vessels of unlimited size packed with borosilicate-glass raschig rings are specified in the standard. The concentration of these solutions is expressed as the mass of plutonium or of uranium per unit volume. The density of hydrogen in any solution cannot be less than 75 g/liter nor greater than 115 g/liter. Limitations on the relative abundance of the various isotopes of plutonium are imposed in the specifications applicable to plutonium solutions. The concentrations specified for uranium enriched in ^{235}U apply regardless of the ^{235}U enrichment but with a limitation on the ^{233}U content. For solutions of uranium containing up to 5.0 wt-% ^{235}U and no ^{233}U, the limitations are expressed as mass of ^{235}U per unit volume. The concentrations specified for solutions of ^{233}U also apply to mixtures of ^{233}U and other uranium isotopes provided the ^{233}U content is greater than 1 wt-% of all the uranium.

C. REGULATORY POSITION

The guidance contained in ANSI/ANS 8.5-1979 for the use of borosilicate-glass raschig rings as a neutron absorber in solutions of fissile material provides a procedure generally acceptable to the NRC staff for the prevention of accidental conditions of criticality.

Section 8.0 of ANSI/ANS 8.5-1979 lists additional documents referred to in the standard. The specific applicability or acceptability of these listed documents will be covered separately in other regulatory guides, where appropriate.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plan for using this regulatory guide.

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[*] Lines indicate substantive changes from previous issue.

[1] Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
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7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

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The methods described in this guide were applied in a number of specific cases during reviews and selected licensing actions. These methods reflect the latest general NRC approach to criticality safety in operations involving use of borosilicate-glass raschig rings as a neutron absorber in solutions of fissile material. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described herein will be used after the issuance of this guide in the evaluation of submittals in connection with license applications submitted under 10 CFR Part 70.

VALUE/IMPACT STATEMENT

The NRC staff performed a value/impact assessment to determine the proper procedural approach for updating Regulatory Guide 3.1, "Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material," dated January 1973, which endorsed ANSI Standard N16.4-1971. The NRC staff has been involved in the development, review, and approval of a revision to ANSI N16.4-1971 (designated ANSI/ANS 8.5-1979), which was approved by the American National Standards Institute on October 9, 1979. The assessment resulted in a decision to develop a revision to Regulatory Guide 3.1 that would endorse, with possible supplemental provisions, ANSI/ANS 8.5-1979. The results of this assessment were included in a draft regulatory guide on this subject that was issued for public comment in May 1981. Since no comments have been received from the public, there has been no need to change the regulatory position of the proposed revision to Regulatory Guide 3.1. A copy of the draft regulatory guide and the associated value/impact statement (identified by its task number, FP 027-5) is available for inspection and copying for a fee at the Commission's Public Document Room at 1717 H Street NW., Washington, D.C.

6- 2/3.46

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REGULATORY GUIDE 3.46
(Task FP 818-4)

STANDARD FORMAT AND CONTENT OF LICENSE APPLICATIONS, INCLUDING ENVIRONMENTAL REPORTS, FOR IN SITU URANIUM SOLUTION MINING

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

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10. General

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INTRODUCTION

A Nuclear Regulatory Commission (NRC) source and byproduct material license is required under the provisions of Title 10, Code of Federal Regulations, Part 40, "Domestic Licensing of Source Material," to recover uranium by in situ solution mining techniques (in situ leaching). An applicant for a research and development or commercial-scale license or for the renewal or amendment of an existing license is required to provide detailed information on the facilities, equipment, and procedures to be used and an environmental report that discusses the operation's impact on the health and safety of the public and on the environment. This information is used by the Commission to determine whether the applicant's proposed activities will, among other things, result in undue risk to the health and safety of the public or adversely affect the environment. General guidance for filing an application and an environmental report is provided in § 40.31, "Applications for Specific Licenses," of 10 CFR Part 40 and in 10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," respectively. The purpose of this guide is to provide specific guidance on the format* and content of an application, including an environmental report, for an in situ uranium solution mining facility license. Applications for licenses authorizing research and development studies are treated in a similar but less comprehensive manner than commercial-scale operations since such activities are not considered to be major Federal actions.

This guide is intended to provide instructive guidance. It should not be considered as a substitute for a careful evaluation of a program proposed by an applicant. Information not specifically discussed in this guide should be included in the application if it is a part of an applicant's proposed or existing operations or health and safety or environmental protection program. In some cases, information discussed in this guide may not be appropriate or necessary depending on site-specific characteristics and circumstances. In those cases, an applicant should describe why the information is not necessary or appropriate. An incomplete application will result in processing delay and may result in the rejection of a license application.

Changes to existing licensed activities and conditions require the issuance of an appropriate license amendment. An application for such an amendment should describe the proposed changes in detail and should discuss the potential environmental and health and safety impacts, using the appropriate sections of this document for guidance.

Filing an Application

The National Environmental Policy Act (NEPA) of 1969 (83 Stat. 852), implemented by Executive Order 11514 and the Council on Environmental Quality regulations of July 30, 1979 (44 FR 55978), requires all agencies of the Federal Government to prepare detailed environmental statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The principal objective of the NEPA is to build into the agency decisionmaking process an appropriate and careful consideration of the environmental impacts of the proposed actions. The NRC licensing and regulatory policies and procedures for the preparation and processing of environmental impact statements and related documents such as environmental impact appraisals in accordance with the NEPA are set forth in 10 CFR Part 51.

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*In cases where an applicant is also required to file an application with the licensing or permitting agency of a non-Agreement State, the applicant should consult with the NRC and the State agency prior to preparing the application so that a format agreeable to both agencies can be developed. This will provide the applicant with an opportunity to prepare a single application document and/or environmental report that would satisfy both State and Federal agencies.

The provisions of paragraph 40.31(f) of 10 CFR Part 40 and of 10 CFR Part 51 require the submittal of both a license application (Form NRC-2) and a separate environmental report for certain activities requiring an NRC source and byproduct material license, including in situ uranium solution mining operations. In view of the nature of an in situ uranium solution mining operation, where the major consideration of both an applicant's submittal and the staff's review is the assessment of environmental impacts of the proposed activity, it appears reasonable that an application and environmental report for an in situ uranium solution mining license should consist of a single document (hereinafter referred to as the application) containing the information discussed herein.

An application for a new commercial-scale license should be filed at least 12 months prior to planned construction for the proposed operation. An application for a new research and development license should be filed at least 6 months prior to planned construction for the proposed operation. An application for a renewal of an existing license should be filed at least 30 days prior to the expiration date of the existing license. An application for an amendment to an existing license should be filed with sufficient lead time to permit a detailed assessment by the NRC staff and issuance of the required authorization before the proposed modification is scheduled to be implemented. All applications must be accompanied by a remittance in the full amount of the fee specified in § 170.31 of 10 CFR Part 170, "Fees for Facilities and Materials Licenses and Other Regulatory Services Under the Atomic Energy Act of 1954, As Amended." Applications may be filed with the Director, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, or may be filed in person at the Commission's offices at 1717 H Street NW., Washington, D.C., or 7915 Eastern Avenue, Silver Spring, Maryland.

Section 51.40 of 10 CFR Part 51 requires an applicant for a license authorizing commercial-scale in situ uranium solution mining to submit to the Director of Nuclear Materials Safety and Safeguards 15 copies of the application described above. The applicant is also required to retain an additional 85 copies of the application for distribution to Federal, State, and local authorities in accordance with written instructions issued by the Director of Nuclear Materials Safety and Safeguards. An applicant for a license authorizing research and development in situ uranium solution mining or for amendments or renewals for any in situ uranium solution mining operation should submit 10 copies of the application and/or environmental report to the Director, Office of Nuclear Materials Safety and Safeguards.

In situ uranium solution mining licenses are generally issued for 5-year periods and are renewable over the life of the project. License renewal applications are processed in a manner similar to that used for new applications. Operational experience, site-specific data, and proposed continuing activities are the primary factors considered by the NRC staff in processing renewal applications.

Presentation of Information

The applicant should strive for clear, concise presentation of the information in the license application. Each subject should be treated in sufficient depth and with sufficient documentation* to permit the Commission to independently evaluate the information presented. An evaluation of information or data should clearly state the conclusions of the evaluation and should present the analyses and supporting data in sufficient detail to permit an independent reviewer to verify this result. Tables, line drawings, and photographs should be used wherever they contribute to the clarity and brevity of the application. The number of significant figures stated in numerical data should reflect the accuracy of the data. Descriptive and narrative passages should be brief and concise. In cases where test results to support conclusions are presented, the procedures, techniques, and equipment used to obtain the test data should be included.

Information previously submitted to the Commission may be incorporated into the application by reference. Each reference should be clear and specific, i.e., the reference should indicate by document, date, page, and paragraph the information the applicant wishes to reference and how such information is pertinent.

Pertinent published information relating to a proposed site or facility and its surroundings should be referenced. Where published information or assumptions may be essential to evaluate specific aspects of the proposed activities, they should be included in summary or verbatim form or as an appendix to the application.**

An in situ uranium solution mining operation may include one or more ore bodies or well fields in the same general area plus an associated processing plant. An applicant should address all projected activities to the extent possible over the anticipated lifetime of operations. If the proposed operation is at the site of other licensed uranium recovery activities, an applicant should consider the cumulative or synergistic effects of directly associated activities.

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*Documentation as used in this guide means presentation of information, supporting data, and statements and includes (1) references to published information, (2) citations from the applicant's experience, and (3) references to unpublished information developed by the applicant or the applicant's consultants. Statements not supported by documentation may be acceptable provided the applicant identifies them as such or as expressions of belief or judgment.

**The distinction between pertinent and essential hinges on the effect that the information may have on the review of potential impacts to public health and safety and the environment. Useful information that is not likely to impact public health and safety or the environment is pertinent, whereas information that may reasonably be necessary for the review to ensure protection of public health and safety and the environment is essential.

All pages of the application should be numbered and dated. Any changes to the original license application or environmental report made prior to issuance of a source material license should be submitted to the NRC in the form of replacement pages, figures, charts, graphs, or tables. The date of the change should be included on each page of replacement material. The applicant should review the entire application and related documents to eliminate any contradictory statements or proposals that may result from changes to a particular chapter or section.

Contents of an Application

The application should contain the information specified in items 1 through 8 of Form NRC-2. The information required in items 9 through 14 of Form NRC-2 should be incorporated into the various items identified in the chapters of this Standard Format that primarily address processing, in-plant radiation safety, and environmental considerations. Particular attention should be given to the information requested in Chapter 5, "Operations," of this Standard Format. Compliance with the specifications delineated in Chapter 5 is normally made a specific condition of the NRC operating license. The written specifications to be presented in the application in accordance with Chapter 5 (these written specifications are required by paragraph 40.31(h) of 10 CFR Part 40) are related to information in other chapters. Accordingly, Chapter 5 of this Standard Format should be reviewed in connection with other information throughout the total application. The following environmental concerns must also be fully addressed in these chapters:

1. The environmental impact of the proposed action,

2. Any adverse environmental effects that could not be avoided if the proposal were implemented,

3. Alternatives to the proposed action,

4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

5. Irreversible and irretrievable commitments of resources involved in the proposed action if it were implemented.

1. PROPOSED ACTIVITIES

This chapter of the application should summarize the overall proposed activities for which a license is requested in sufficient detail to permit the reviewer to obtain a basic understanding of the proposed activities and potential environmental impact. Review of the chapters that follow can then be accomplished with a better perspective and with recognition of their relative importance to the overall operations. The following subjects should be addressed: the corporate entities involved; the location of the proposed activities; land ownership; ore-body locations and estimated U_3O_8 content; proposed solution mining method and recovery process; operating plans, design throughput, and anticipated annual U_3O_8 production; estimated schedules for construction, startup, and duration of operation; plans for project waste management and disposal; plans for ground-water-quality restoration, decommissioning, and land reclamation; and surety arrangements covering eventual facility decommissioning, ground-water-quality restoration, and site reclamation. Applications for licenses authorizing commercial-scale operations should rely heavily on results from research and development operations as a basis for the proposed processes, operating plans (including plans for ground-water-quality restoration), and assessment of potential environmental impact.

2. SITE CHARACTERISTICS

This chapter should present the basic relevant information concerning those physical, ecological, demographic, and social characteristics of the environs that might be affected by the proposed operations. To the extent possible, the information presented should reflect observations and measurements made over a sufficient period of time to allow defensible conclusions to be reached.

2.1 Site Location and Layout

Provide a map showing the site and its location with respect to any Federal land and to State, county, and other political subdivisions. On detailed maps, show the location of the proposed in situ uranium solution mining operations; well fields and all principal structures (e.g., waste ponds, evaporation ponds, recovery plant); exclusion area boundaries and fences; applicant's property; adjacent properties, including water bodies, wooded areas, and farms; nearby settlements; and transportation links (e.g., railroads, highways, waterways). Indicate total acreage owned or leased by the applicant and that part occupied or modified by the proposed activity. Also indicate other existing and proposed uses of the applicant's property and the acreage devoted to these uses. A contour map of the site should be supplied with elevation contours of an interval suitable to show significant variations of the site environs and drainage gradients. For clarity, this information should be supplied on separate maps.

2.2 Uses of Adjacent Lands and Waters

Indicate, within a 3.3-km (2-mi) radius [0.8 km (0.5 mi) for research and development operations], the nature and extent of present and projected land use (e.g., agriculture, sanctuaries, hunting, grazing, industry, recreation, roads) and any recent trends of changes in population or industrial patterns. In addition, for commercial-scale operations, identify any other nuclear fuel cycle facilities located or proposed within an 80-km (50-mi) radius of the site.

Provide in tabular form for each of the 22-1/2-degree sectors centered on each of the 16 compass points, i.e., north, north-northeast, etc., the distances (to a distance of 3.3 km (2 mi)) from the center of the site to the following:

1. Nearest residence.

2. Nearest site boundary.

Identify the location, nature, and amounts of present and projected surface- and ground-water use (e.g., water supplies, irrigation, reservoirs, recreation, and transportation) within 3.3 km (2 mi) of the site boundary [0.8 km (0.5 mi) for research and development operations] and the present and projected population associated with each use point, where appropriate.

Data on both present and projected future water use(s) should be summarized and tabulated; users should be located on maps of legible scale. Tabulations should include:

1. Location: Include symbols shown on maps identifying the location of water users. Provide map coordinates if appropriate.

2. Distances from proposed uranium solution mining well fields.

3. Withdrawal Rate: Provide present and projected withdrawal rate for each water use. For ground-water uses, indicate depth of wells, ground-water elevations, flow rates, interval(s) screened, drawdown, and aquifers from which water is withdrawn, and characterize the uses of the aquifers.

4. Return Rates: Provide present and projected return rates if appropriate.

5. Type of Water Use: Provide the type of water use for each location, e.g., municipal, industrial, irrigation, stock and game watering.

6. Source and Projection of Water-Use Estimates: Where use rates are anticipated to change over the life of the project and beyond, indicate projections and the source of the projection information. Sources for such projections may be available from users or planning agencies at different levels of government.

7. Abandoned Wells: Furnish a tabulation of all abandoned wells and drill holes giving the location, depth, type of use, condition of closing, plugging procedure used, and date of completion for each well or drill hole within the site area and within 0.4 km (0.25 mi) of the well-field boundary. This information is generally available from public records and from inspection of the area.

For items 3 and 4 above, indicate monthly values if seasonal use varies significantly.

2.3 Population Distribution

Population data presented should be based on the most recent census data. On a map of suitable scale that identifies places of significant population grouping such as cities and towns within an 80-km (50-mi) radius [3.2 km (2 mi) for research and development operations] from the approximate center of projected activities, concentric circles should be drawn, with the site at the center point, at distances of 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km. The circles should be divided into 22-1/2-degree sectors with each sector centered on one of the 16 compass points, i.e., north, north-northeast, northeast, etc. A table appropriately keyed to the map should provide the current residential population within each area and for census years through the anticipated life of the operation. The table should provide separate and cumulative population totals for each sector and annular ring. Distance to the nearest residence should be noted for each sector. The basis for population projections should be described.

In addition, for commercial-scale operations, descriptive material should include tables giving significant population and visitor statistics of neighboring schools, plants, hospitals, sports facilities, residential areas, parks, etc., within 3.3 km (2 mi) of the solution mining operations. The material should also include appropriate available food production data in kg/yr for vegetables (by type and totals), meat (all types), and milk and any available future predictions by local governmental, industrial, or institutional organizations within 3.3 km (2 mi) of the site boundary.

2.4 Regional Historic, Archeological, Architectural, Scenic, Cultural, and Natural Landmarks

The application should include a brief discussion of the historic, scenic, archeological, architectural, cultural, and natural significance, if any, of the proposed site and nearby areas with specific attention to the site and nearby areas listed in the National Registry of Natural Landmarks and properties included in or eligible for inclusion in the National Register of Historic Places.

The National Registry of Natural Landmarks appears in the Federal Register (37 FR 1496). The National Register of Historic Places also appears in the Federal Register (44 FR 7416) where additions are published annually. General guidance on the treatment of historic, archeological, architectural, and cultural features can be obtained from the National Park Service publication entitled "Preparation of Environmental Statements: Guidelines for Discussion of Cultural (Historic, Archeological, Architectural) Resources," August 1973.*

The application should identify those properties included in or eligible for inclusion in the National Register of Historic Places located within the area of the proposed project. The applicant should also consult with the appropriate State Historic Preservation Officer (SHPO) concerning the identification of properties included in or eligible for inclusion in the National Register of Historic Places. The application should contain evidence of contact with the appropriate SHPO. A copy of the SHPO's comments concerning the effect of the facility on historic, archeological, architectural, and cultural resources should be included in the application.

State whether new roads, pipelines, and utilities for the proposed activity will pass through or near any area or location of known historic, scenic, cultural, natural, archeological, or architectural significance.

2.5 Meteorology

This section should provide a description of the meteorological diffusion characteristics of the site and its surrounding area. The description should be based on data collected on site and/or at nearby local meteorological stations. Sufficient data should be included to permit independent evaluations and assessments of atmospheric diffusion characteristics. Based on past application reviews of research and development operations, detailed meteorological data (other than basic wind speed and direction and precipitation/evaporation data) are not needed.

The following data concerning site meteorology from meteorological measurements taken on site and/or at nearby representative stations should be provided:

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*Copies may be obtained from Chief Historian, Room 1226, National Park Service, 18th and C Streets NW., Washington, D.C. 20240.

1. Joint frequency data
    a. National Weather Service (NWS) station data
        (1) Locations of all NWS stations within an 80-km (50-mi) radius
        (2) Available joint frequency distribution data by wind direction, wind speed, and stability class (3-dimensional numerical array)
        (3) Period of record by month and year
        (4) Height of data measurement
    b. Onsite meteorological data
        (1) Locations and heights of instrumentation
        (2) Description of instrumentation
        (3) Minimum of 1 full year of onsite joint frequency distribution data broken down by wind direction, wind speed, and stability class (3-dimensional array) with a joint data recovery of 90 percent or more
2. Miscellaneous data
    a. Annual average mixing layer heights
    b. Description (general) of regional climatology, particularly including frequencies and durations of extreme wind speeds
3. Total precipitation and evaporation by month

This information should be fully documented and substantiated as being representative of expected long-term conditions at and near the site.

The joint wind speed-stability-direction frequencies should be presented in tabular form, giving the frequencies as fractions when using 5-year NWS summaries or as the number of occurrences when using only 1 or 2 years of onsite data. The data should be presented for each of the 16 compass directions, and the stability categories should be established to conform as closely as possible with those of Pasquill. In addition, the annual average inversion height should be provided from other nearby weather stations.

Guidance on acceptable onsite meteorological measurements and data format is presented in Regulatory Guide 1.23 (Safety Guide 23), "Onsite Meteorological Programs."

In addition, this section should provide a discussion of general climatology, existing levels of air pollution, the relationship of the meteorological data gathered on a regional basis to local data, the impact of the local terrain and large lakes and other bodies of water on meteorological conditions in the area, and the occurrence of severe weather in the area and its effects. Data on diurnal and monthly averages of temperature and humidity should also be provided.

2.6 Geology and Seismology

A description of the geology of the site and establishment of the continuity of the geologic environs represented in the strata at the site should be included in the application. The discussion should note local and regional stratigraphy, structure, and tectonic history and should include geologic features such as dips, faulting, fracturing, and continuity of geologic strata at the site and in nearby regions. Structural and stratigraphic maps and cross sections, with representative core and geophysical well-log data, of the site and its environs should be included. Also include an isopach map of the intended zone of injection or production and confining beds. Conclusions concerning the geology, particularly the lateral continuity and vertical thickness of the ore zone(s), surrounding lithologic units, and confining zones, should be based on lithologic logs from core and drill cuttings, geophysical data, remote-sensing measurements, and the results of other appropriate investigations that are needed to define the geology. Geologic and geophysical logs and other data should be furnished in an appendix. Proprietary data should be so designated and kept separate from the remainder of the application.

An inventory of economically important minerals and energy-related deposits, in addition to the uranium ore, should be included in the discussion. Data defining the geochemistry of the ore zone and the geologic zones immediately surrounding the ore zone that will or could be affected by injected lixiviant should be included. Unique minerals (including those that might be affected by fluid movement associated with the proposed project such as bentonite) or paleontological deposits of particular scientific interest should also be identified. Any effect that planned operations might have on the future availability of other mineral resources should be noted.

Discuss the seismicity (including its history) of the region. Where possible, associate seismic events with tectonic features identified above. Furnish a regional earthquake epicenter map showing site location.

2.7 Hydrology

The effects of well construction and well-field operation on adjacent surface and ground waters and the effective control and monitoring of subsurface process fluids are of prime importance. The applicant should describe in quantitative terms the physical, chemical, biological, radiological, and hydrological characteristics; the typical seasonal ranges and averages; and the historical extremes for surface-water bodies and aquifers associated with the proposed project. Ranges, averages, and extremes should be evaluated to the extent that such characteristics can be distinguished from possible excursions during operations. Water-quality data should include measurements made both at and in close proximity (within 200-400 feet) of the proposed in situ uranium solution mining areas (well fields). NRC staff Technical Position Paper* WM-8102, "Groundwater Monitoring at Uranium In Situ Solution Mines," should be reviewed in connection with this section. The position paper provides specific guidance for obtaining both surface- and ground-water-quality baseline data.

2.7.1 Ground Water

The hydrology of both regional and local ground-water systems should be described. The description of the ground-water setting should include identification of the average thickness, lateral extent, general flow direction, average yield, and premining water elevation maps of the regional aquifer, the ore zone aquifer, and surrounding aquifers that might be affected.

Within the local ground-water systems, all aquifers that may be affected by the proposed in situ uranium solution mining operations should be identified. The hydrologic properties of the local aquifers, including aquifer thickness, distribution of potentiometric levels, flow gradients, flow directions, flow velocities, directional permeabilities, transmissivities, storage coefficients, and porosities, should be described in detail. Confining beds or other lithologic units separating the ore zone(s) from other aquifers should be described. Vertical permeabilities, horizontal permeabilities, competence, lateral extent, and other data sufficient for evaluation of the confining properties of the beds with respect to preventing excursions should also be defined. A description of soil types and near-surface material, including hydrologic properties, should be presented in sufficient detail to permit evaluations of the effects of surface activities related to the proposed uranium mining operations. Conclusions concerning the hydrologic characteristics of site aquifers and confining beds and soil types should be based on well borings and cores, aquifer pumping tests, laboratory permeability tests, soil surveys, and the results of other appropriate investigations needed to define the hydrology.

Descriptions of local ground-water wells, including well location, uses, amounts used, depth, screened intervals, yield, static water level, and preoperational water quality used, should be presented in the application. The descriptions should be in sufficient detail to fully define the uses and sources of ground water in the project environs.

All project-related wells, including well location, elevation, depth, screened intervals, static water level, and preoperational water quality, should be described in the application.

The preoperational water quality of all aquifers that might be affected by the proposed operations, as well as the changes expected in quality due to the solution mining activities, should be described.

Data and analysis of pumping tests, water-quality measurements, and other tests should be furnished to verify all hydrologic interpretations and conclusions. Methods of testing and analysis should also be described.

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*NRC staff technical position papers that are referenced in this Standard Format may be obtained from the Director, Division of Waste Management, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

2.7.2 Surface Water

Describe the location, size, shape, and hydrologic characteristics and uses of surface-water bodies in the environs of the site.

Include a description of upstream and downstream river control structures, and provide a topographic map showing the major hydrologic features. Water-quality analysis and flow rates from U.S. Geological Survey gaging stations in nearby environs should be included.

In the vicinity of evaporation ponds near drainage courses or where surface runoff is rerouted, the drainage areas of the water courses should be delineated. Where an embankment prevents surface runoff from entering or threatening an impoundment, stream cross sections in the impoundment vicinity should be provided to clearly show the vertical and horizontal relationships of the channel and the pond embankments.

2.8 Ecology

In this section, the applicant should describe the flora and fauna in the vicinity of the site, their habitats, and their distribution. This inventory should identify species that may require specific attention because of their importance to the community. A species is important (for the purposes of this guide) if a specific causal link can be identified between the facility and the species and if one or more of the following criteria applies: (1) the species is commercially or recreationally valuable, (2) the species is threatened or endangered,* (3) the species affects the well-being of some important species within criterion (1) or (2), or (4) the species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides or chemical pollutants in the environment.

The inventory should establish the identity of the majority of the terrestrial and aquatic organisms on or near the site and their relative (qualitative) abundance. The applicant should identify the important species from this list and should discuss in detail their quantitative abundance. This discussion should include species that migrate through the area or use it for breeding grounds. Special attention should be given to the relative importance of the proposed site environs to the total regional area for the living resources (potential or exploited).

For commercial-scale operations and for research and development operations involving drying of yellowcake, the applicant should provide data on the count and distribution of important domestic fauna, in particular, cattle, sheep, and other meat animals that may be involved in the exposure of man to radionuclides. Important game animals should receive similar treatment. A map showing the distribution of the principal plant communities should be provided.

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*In the writing and reviewing of environmental reports, specific consideration should be given to possible impact on any species (or its habitat) that has been determined to be endangered or threatened with endangerment by the Secretary of the Interior and the Secretary of Commerce. New terminology defining "endangered or threatened with endangerment" has been issued in Public Law 93-205, 87 Stat. 884.

The discussion of species-environment relationships should include descriptions of area usage (e.g., habitat, breeding) for important species; life histories of important regional animals and aquatic organisms, their normal seasonal population fluctuations, and their habitat requirements; and identification of food chains and other interspecies relationships, particularly when these are contributory to predictions or evaluations of the impact of the facility on the regional biota.

Any definable preexisting environmental stresses from sources such as pollutants, as well as pertinent ecological conditions suggestive of such stresses, should be identified. The status of ecological succession should be described.

The information should be presented in two separate subsections: "Terrestrial Ecology" and "Aquatic Ecology." The sources of information should be identified. As part of this identification, a list of pertinent published material dealing with the ecology of the region should be presented. All ecological or biological studies of the site or its environs currently in progress or planned should be referenced and described.

2.9 Background Radiological Characteristics

Report site-specific radiological data, including both natural background radiation levels and results of measurements of concentrations of radioactive materials occurring in important biota, in soil, in air, and in surface and ground waters that could be affected by the proposed activities. These data, whether determined during the applicant's preoperational surveillance program or obtained from other sources, should be referenced. NRC staff Technical Position Paper WM-8102 should be reviewed in connection with background (baseline) surface- and ground-water-quality monitoring programs.

2.10 Background Nonradiological Characteristics

Site-specific nonradiological characteristics, particularly those that are related to expected site-related effluents, should be reported. Data should include such indicators as heavy metals and other potentially toxic substances in surface and ground waters, atmospheric pollutants, dusts, etc., that could affect water or air quality. Other regional sources of these same materials should be noted along with a discussion of the possible incremental contribution to the existing levels found at the site. NRC staff Technical Position Paper WM-8102 should be reviewed in connection with background (baseline) surface- and ground-water-quality monitoring programs.

2.11 Other Environmental Features

Some relevant information on the environs may not clearly fall within the scope of the preceding topics. Additional information may be required with respect to some environmental features in order to reflect the value of the site and site environs to important segments of the population. Such information should be included in this section.

Much of the information from the preceding topics will be used by the NRC to perform an independent assessment of offsite radiological impacts. Detailed computer assessments are performed for commercial-scale operations. Suggested formats for supplying much of the information necessary for an independent assessment of offsite radiological impacts resulting from the operation of a proposed commercial-scale facility are included as Appendix A to this guide.

3. DESCRIPTION OF PROPOSED FACILITY

The in situ uranium solution mining operation should be described in this chapter. Since environmental effects are of primary concern, the combined effects of mining effluents and related systems that interact with the environment should be described in sufficient detail to permit an independent evaluation by the NRC of the proposed project.

3.1 Solution Mining Process and Equipment

The entire in situ solution mining process should be described in sufficient detail to permit evaluation of all operations and processes involved. This description would include data about the ore bodies, the feasibility of processing defined well-field areas, well construction techniques and integrity testing procedures to ensure that well installations will not result in hydraulic communication between production zones and overlying or underlying aquifers, how wells and ponds will be completed, injection/production rates and pressures, proposed operating plans and schedules, details of the proposed uranium recovery facility and its operation, plant material balances and flow rates, lixiviant makeup and recovery efficiency, and major constituents and their concentrations in the gaseous, liquid, and solid wastes and effluents that will be generated in the process. The following should also be provided:

1. A map or maps showing the proposed sequence and schedules for the in situ uranium solution mining well-field area(s) and well-field ground-water-quality restoration operations,
2. A flow diagram of the process and/or circuit,
3. A material balance diagram,
4. A description of any chemical recycle systems,
5. A water balance diagram for the entire system, and
6. A map or maps showing the proposed sequence and schedules for land reclamation of the well-field areas.

3.2 Recovery Plant Equipment

A physical description and operating characteristics for the proposed major items of process equipment should be provided. A diagram of the proposed plant layout, indicating areas and points where dusts, fumes, or gases would be generated, should be included. The diagram should also show the locations of all ventilation, filtration, confinement, and dust collection systems, as well as the location of the radiation monitoring equipment identified in Chapters 4, "Effluent Control Systems," and 5, "Operations."

3.3 Instrumentation

A description of proposed process instrumentation and control systems relevant to safety and radiation safety sampling and monitoring instrumentation, including their minimum specifications and operating characteristics, should be provided. This includes well-field process control equipment for monitoring injection pressures and rates and production rates. Sufficient information should be included to permit an evaluation of the interrelationship between instrumentation systems and the operations or processes to be controlled or monitored.

4. EFFLUENT CONTROL SYSTEMS

4.1 Gaseous and Airborne Particulates

Provide a description of all proposed ventilation, filtration, and confinement systems that are to be used during operations to control the release of radioactive materials to the atmosphere. Include an analysis of equipment as designed and operated to prevent radiation exposures to employees and to limit such exposures to as low as is reasonably achievable (ALARA). The definition and operating philosophy for ALARA are contained in paragraph 20.1(c) of 10 CFR Part 20 and in Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable." Also include a physical description of discharge stacks, types and estimated composition and flow rates of atmospheric effluents, and proposed methods for controlling such release levels ALARA.

4.2 Liquids and Solids

To the extent that information is not provided in Section 3.1, provide a realistic estimate of the quantities and composition of all waste residues expected, along with proposed procedures for their management. Where retention systems such as ponds are to be used to prevent the release of liquid or solid wastes containing radioactive material, provide the information specified in Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," and describe the type of liner and leak detection system proposed, as well as the quality assurance program to be used for installation of the liner and leak detection system. Also provide descriptions and design details for all temporary and permanent surface-water diversion facilities. NRC staff Technical Position Papers WM-8101, "Design, Installation, and Operation of Natural and Synthetic Liners at Uranium Recovery Facilities"; WM-8201, "Hydrologic Design Criteria for Tailings Retention Systems"; and "Explorations for Design and Evaluation of Uranium Mill Tailings Retention Systems," should be consulted in addition to Regulatory Guide 3.11 to provide design criteria acceptable to the NRC staff. Describe contingency plans to mitigate any environmental impact in the event that leakage occurs from impoundments containing potentially harmful materials. (See § 20.301 of 10 CFR Part 20.)

If effluents are to be released into waters of the United States, provide a discussion of the status of efforts to obtain a water-quality certification under Section 401 and discharge permits under Section 402 of the Federal Water Pollution Control Act, as amended, or submit copies of these items if already issued.

4.3 Contaminated Equipment

Provide a description of the methods for disposing of contaminated waste solids (e.g., ion exchange resins, filters, filter presses, obsolete or worn-out equipment) that are generated in the uranium recovery process.*

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*See Branch Technical Position, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated November 1976. Copies may be obtained from the Director, Division of Waste Management, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

5. OPERATIONS

Compliance with the statements, representations, and procedures provided in this chapter will normally be made a specific condition of the NRC source material license. Thus, the sections of this chapter should be considered as specific commitments on the part of the applicant for conducting operations, radiological protection programs, and all monitoring programs. In addition, the bases for all programs addressed in this chapter, as well as the demonstration of their adequacy, should be provided. In order to facilitate administration of the license by the licensee and NRC, this chapter should be complete in itself, insofar as possible, without references to other submittals.* The requirements of 10 CFR Part 20 are an integral part of this chapter. Specific sections of 10 CFR Part 20 are referenced where appropriate.

5.1 Corporate Organization and Administrative Procedures

Provide a detailed description of the applicant's proposed organization, including authority and responsibility of each level of management and supervision with regard to development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and ground-water monitoring programs and associated quality assurance programs, routine and nonroutine maintenance activities, and changes in any of the above.

5.2 Management Control Program

Describe the proposed management control program and administrative procedures to ensure that all activities are conducted in accordance with written operating procedures that will be approved and reviewed at specified frequencies by the applicant's radiation safety staff. This program should provide a method for ensuring that any nonroutine work or maintenance activity not covered by an effective operating procedure will be conducted in accordance with a special work permit reviewed and approved by the applicant's radiation safety staff.

5.3 Management Audit and Inspection Program

Describe the proposed management audit and internal inspection program, including frequencies and types and scopes of reviews and inspections, action levels, and corrective action measures. Identify by management position the person responsible for each phase of the audit and inspection program. Also provide a detailed description of the program for ensuring that employee exposures (to both airborne and external radiation) and effluent releases are as low as is reasonably achievable (ALARA program). (See paragraph 20.1(c) of 10 CFR Part 20.)

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* Draft Regulatory Guides OH 941-4, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable," OH 710-4, "Health Physics Surveys in Uranium Mills," and Regulatory Guide 8.22, "Bioassay at Uranium Mills," should be reviewed in connection with this chapter. Although these guides are for uranium mills, some of the guidance may be applied to solution mining recovery plants since the basic processes and potential for exposing workers to uranium and its daughters in a recovery plant are similar to those of certain milling operations.

5.4 Qualifications

Provide a description of the minimum qualifications and experience required for personnel holding positions in the applicant's proposed organization who will be assigned the responsibility for developing, conducting, and administering the radiation safety program. Describe in an appendix the qualifications of the persons currently proposed for these positions. (In cases where specific individual appointments may not have been made when an application was filed, minimum specifications will suffice.)

5.5 Training

Provide a description of the proposed employee radiological protection training program, including the content of the initial training or indoctrination, testing, on-the-job training, and extent and frequency of retraining. In an appendix in conformance with § 19.12 of 10 CFR Part 19, provide a copy of the proposed written radiological safety instructions to be provided to employees. These instructions should include provisions for personal hygiene (including washing), for contamination surveying prior to eating or leaving the operating area, for wearing personnel monitoring devices and respirators, for good housekeeping requirements, for cleaning up spills within the site boundary, and for emergency action in the event of accidents.

5.6 Security

Provide a description of the proposed method for preventing unauthorized entry into the controlled area. (See § 20.203 of 10 CFR Part 20.)

5.7 Radiation Safety Controls and Monitoring

Paragraph 20.1(c) of 10 CFR Part 20 states that "... persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable." Regulatory Guide 8.10 provides the NRC staff position on this important subject. License applicants should give consideration to the ALARA philosophy, as described in Regulatory Guide 8.10, in the development of plans for work with licensed radioactive materials. The following material should be provided.

5.7.1 Effluent Control Techniques

Describe the proposed systems and procedures designed to minimize in-plant and environmental emissions at each step of the process where releases might occur. Provide the minimum performance specifications such as filtration or scrubber efficiency and airflow for operating the ventilation, filtration, and confinement systems throughout the recovery plant and associated laboratories at their reasonably expected best performance and the frequency of tests and inspections to ensure that these specifications are being met. Include descriptions of the contingency plans to be implemented in the event of equipment failures or spills.

5.7.2 External Radiation Exposure Monitoring Program

Describe the proposed methods, instrumentation, and equipment for determining exposures of employees to external radiation, in conformance with § 20.101 of 10 CFR Part 20, during routine and nonroutine operations, maintenance, and cleanup activities. Also describe the type of surveys to be conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. For personnel monitoring devices such as film badges, indicate the number and category of personnel involved in the program and the sensitivity and range of the devices. For survey instruments, provide instrument sensitivities, ranges, calibration methods (in an appendix), and frequency of calibration. (See §§ 20.201 and 20.202 of 10 CFR Part 20.)

5.7.3 Airborne Radiation Monitoring Program

Describe the proposed sampling program to determine concentrations of airborne radioactive materials (including radon) during routine and nonroutine operations, maintenance, and cleanup activities. (See §§ 20.103, 20.201, and 20.203 of 10 CFR Part 20.) In the description of the sampling program, include:

1. The criteria for determining sampling locations with respect to process operations and personnel occupancy; and

2. The frequency of sampling, type of analyses, sensitivity of overall sampling and analyses, action levels, management audits, corrective action requirements, and instrumentation calibration frequency. Procedures for sample analyses and instrument calibration should be included in an appendix.

5.7.4 Exposure Calculations

Describe the proposed procedure, in conformance with § 20.103 of 10 CFR Part 20, to determine the intake of radioactive materials by personnel in work areas where airborne radioactive materials could exist. Include those exposures incurred during nonroutine operations, maintenance, and cleanup activities as well as during routine activities.

5.7.5 Bioassay Program

Describe the proposed bioassay program to confirm the results derived from the programs identified in Sections 5.7.3 and 5.7.4. Indicate the number and category of personnel involved in the program, the types and frequencies of bioassays performed, and action level criteria to be applied to bioassay results. (See §§ 20.103 and 20.108 and Appendix B to 10 CFR Part 20.)

5.7.6 Contamination Control Program

Describe the proposed occupational radiation survey program to determine that employees (plus their workclothes or coveralls, etc.) entering clean areas (lunchrooms, offices, etc.) or leaving the site are not contaminated with radioactive materials. The description should include proposed housekeeping and cleanup requirements and specifications in process areas to control contamination; frequency of surveys of clean areas; survey methods; and minimum sensitivity, range, and calibration frequency of survey equipment. Provide proposed contamination criteria or action levels for clean areas and for the release of materials, equipment, and workclothes to clean areas or from the site. Procedures for instrument calibration should be included in an appendix. (See §§ 20.201 and 20.202 of 10 CFR Part 20.) See also Branch Technical Position, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated November 1976.

5.7.7 Airborne Effluent and Environmental Monitoring Programs*

Describe in detail the proposed effluent and environmental monitoring programs, including methods and procedures for measuring concentrations and quantities of both radioactive and nonradioactive materials released to and in the environs. The description of the proposed monitoring programs should include the technical basis used to determine environmental concentrations to show conformance with §§ 20.103, 20.105, and 20.106 of 10 CFR Part 20.

For both effluent and environmental monitoring, the frequency of sampling and analysis, the types and sensitivity of analysis, action levels and corrective action requirements, and the minimum number and criteria for locating effluent and environmental monitoring stations should be provided. Proposed locations should be indicated on a topographic map of the site and surrounding area.

5.7.8 Ground-Water and Surface-Water Monitoring Programs

Describe the monitoring programs to be used to determine if the lixiviant and/or contaminants are in hydrologic communication with other lithologic zones or with ground-water or surface-water supplies or have migrated laterally outside the well-field area. This description should include the technical basis for the monitoring programs, including the number and location of monitoring stations, the criteria used for locating sampling stations and determining sampling frequency, the excursion indicators and criteria used in determining them, and upper control limits for excursion indicators and corrective action requirements. Provide the procedures for sample collection and analyses in an appendix. See NRC staff Technical Position Paper WM-8102 regarding excursion indicator sets, upper control limits, and operational ground-water monitoring. (See §§ 20.103, 20.105, and 20.106 of 10 CFR Part 20.)

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*Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills," should be reviewed in connection with this section.

5.7.9 Quality Assurance*

Describe the quality assurance programs for all radiological and nonradiological in-plant, effluent, and environmental (including ground-water) monitoring programs.

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*Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," should be reviewed in connection with this section.

6. GROUND-WATER-QUALITY RESTORATION, SURFACE RECLAMATION, AND PLANT DECOMMISSIONING

The applicant should describe in detail proposed plans for ground-water-quality restoration, surface reclamation, and plant decommissioning.

Detailed discussions should be provided for the following:

1. Plans and schedule(s) for ground-water-quality restoration, including:

    a. An estimate of the quantities, concentrations, and lateral and vertical extent of those chemicals that may persist in leached-out well-field production zones after termination of in situ mining operations and prior to restoration activities;

    b. A description of proposed methods and techniques to be used to achieve ground-water-quality restoration, including identification of in situ chemical reactions that may hinder or enhance restoration. The applicant should provide an analysis of the methods and techniques to be used to achieve restoration in terms of fluids to be used during restoration and the hydraulic and geochemical properties of the receiving stratum. For commercial-scale operations, the restoration methods and techniques should be based on results obtained from research and development operations. In addition, for commercial-scale operations, a schedule for sequential restoration of mine units should be included;

    c. A description of the expected postreclamation conditions and quality of restored ground waters, compared with the preoperational land and water-quality characteristics;

    d. An assessment of the proposed water-quality restoration operations with respect to adversely affecting ground waters outside production zones; and

    e. The procedures to be used for plugging, sealing, capping, and abandoning all wells associated with the in situ solution mining operations.

2. Plans and schedule(s) for reclaiming disturbed lands, including:

    a. A contour map showing the approximate postreclamation surface contours for affected lands and immediate surrounding area(s);

    b. Procedures for the reclamation of any temporary diversion ditches and impoundments;

    c. Procedures for reestablishing any surface drainage that may be disrupted by the solution mining operations;

    d. Procedures for mitigating or controlling the effects of any subsidence; and

e. Procedures for ground surface preparation, depth of topsoil replacement and revegetation plans, erosion control and water conservation practices, and proposed postoperational land use.

3. Procedures for removing and disposing of structures used in conjunction with the in situ solution mining operations, including procedures for managing all toxic and radioactive materials. In the discussion pertaining to the disposal of wastes produced by in situ solution mining operations, procedures for removal and disposal of byproduct material to an existing uranium mill tailings disposal site or licensed burial site should be included.

4. Procedures for conducting postreclamation and decommissioning radiological surveys to ensure that sufficient potential radioactive contamination has been removed from the site to permit its release for unrestricted use. Include plans for postoperational ground-water monitoring to ensure that restored water quality is stabilized. See NRC staff Technical Position Paper WM-8102 regarding postoperational ground-water monitoring programs.

5. Financial arrangements to be made to ensure that adequate funds will be available for the ground-water-quality restoration, facility decommissioning, land reclamation, offsite disposal of byproduct waste material, and monitoring described above. Such arrangements should be based on a financial assessment of estimated costs, which should also be included.

7. ENVIRONMENTAL EFFECTS

The construction of facilities and well drilling will inevitably affect the environment; some of the effects may be adverse and others beneficial. Effects are considered adverse if environmental change or stress causes a valuable or otherwise important biotic population or natural resource to be less safe, less healthy, less abundant, less productive, less esthetically or culturally pleasing; if the change or stress reduces the diversity and variety of individual choice or the standard of living; or if the change or stress tends to lower the quality of renewable resources or to impair the recycling of depletable resources.

The applicant's discussion of adverse environmental effects should distinguish between those that are considered unavoidable and subject to later amelioration and those that are regarded as unavoidable and irreversible. Those effects representing an irreversible and irretrievable commitment of resources should receive detailed consideration. (In the context of this discussion, "irretrievable commitment of resources" refers to natural resources and means their permanent impairment, e.g., loss of wildlife habitat; destruction of nesting, breeding, or nursing areas; interference with migratory routes; loss of valuable or esthetically treasured natural areas; and expenditure of directly used resources.)

7.1 Site Preparation and Construction

The applicant should organize the discussion in terms of the effects of site preparation and construction on both land use and water use. The applicant should consider the consequences to both human and wildlife populations and should indicate which are unavoidable, irreversible, etc., according to the categorization set forth above.

A description of how construction activities may disturb the existing terrain and wildlife habitats should be included in the land-use discussion. Consider the effects of such activities as building temporary or permanent roads, bridges, or service lines; disposing of trash; excavating; and land filling. Provide information bearing on such questions as how much land will be disturbed and for how long, and will there be dust or smoke problems. Indicate proximity of human populations, and identify undesirable impacts on their environment arising from noise, disruption of stock grazing patterns, and inconvenience due to the movement of men, material, and machines, including activities associated with any provision of housing, transportation, and educational facilities for workers and their families. Describe any expected changes in accessibility of historic and archeological sites in the region. Discuss measures designed to mitigate or reverse undesirable effects such as erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats.

The discussion should also include any effects of site preparation and construction activities the consequences of which may be beneficial to the region.

The discussion of water use should describe the impact of site preparation and construction activities on area water sources. The applicant should describe the effects of these activities on fish and wildlife resources, water quality, water supply, esthetics, etc., as applicable. Describe measures such as pollution control and other procedures for habitat improvement to mitigate undesirable effects.

7.2 Effects of Operations

The impacts of operation of the proposed activity should be, to the fullest extent practicable, quantified and systematically presented in this section. In the discussion of each impact, the applicant should make clear whether the supporting evidence is based on theoretical, laboratory, onsite, or field studies undertaken for this or for previous operations. The source of each impact (the plant subsystem, waste effluent) and the population or resource affected should be made clear in each case. The impacts should be distinguished in terms of their effects on surface-water bodies, ground water, air, land, land use, ecological systems, and important plants and animals, etc.

7.3 Radiological Effects

In this section, the applicant should consider the radiological effects of operations on man. Estimates of the radiological impact on man via various exposure pathways should be provided.

7.3.1 Exposure Pathways

The various possible pathways for radiation exposure of man should be identified and described in textual and flow-chart format. Discuss any exposure pathways, if they exist, involving radionuclide accumulation in specific components of the environment. Suggested formats for supplying information necessary for the NRC independent evaluation of offsite radiological impacts resulting from the operation of a proposed commercial-scale facility are outlined in Appendix A to this guide.

7.3.2 Exposures from Water Pathways

Estimate the expected annual average concentrations of radioactive nuclides in receiving water at locations where water is consumed or is otherwise used by human beings or where it is inhabited by biota of significance to human food chains. Specify the dilution factors used in preparing the estimates and the locations where the dilution factors are applicable. Consideration should be given to the absence of mixing and dilution because of factors such as channeling.

Estimate the expected radionuclide concentrations in aquatic and terrestrial organisms significant to human food chains. Use bioaccumulation factors as necessary.

Using the above information and any other necessary supporting data, calculate the total annual body and significant organ doses (in millirems) to individuals in the population from all receiving-water-related exposure pathways, i.e., all sources of internal and external exposure. Provide an appendix describing details of the models and assumptions used in these calculations.

7.3.3 Exposures from Air Pathways

From release rates of airborne radioactivity and meteorological data, estimate total annual body and significant organ doses (in millirems) to individuals exposed at the point of maximum ground-level concentrations off site, individuals exposed at the site boundary in the direction of the prevailing wind, individuals exposed at the site boundary nearest to the sources of emission, and individuals exposed at the nearest residence in the direction of the prevailing wind. Assume annual average meteorological conditions. Identify locations of points of release (e.g., stack, roof vent) used in these calculations.

Estimate deposition of radioactive materials on food crops and pasture grass. Estimate total annual body doses (in millirems) and significant annual doses received by other organs via such potential pathways.

Provide an appendix describing the models used in these calculations.

7.3.4 Exposures from External Radiation

Provide an estimate of the maximum annual external dose (in millirems) that would be received by an individual from direct radiation at the nearest site boundary.

7.3.5 Total Human Exposures

Provide estimates of the maximum annual doses (in millirems) that could be received via all pathways described above by an individual at the site boundary and at the nearest residence.

For commercial-scale operations, the applicant should also present a table that summarizes the estimated radiation dose to the regional population (within 80 km) from the uranium recovery plant and well-field-related sources using values calculated in previous sections. The tabulation should include the total annual 100-year environmental dose commitment (person-rems) to the population from all pathways.

7.3.6 Exposures to Flora and Fauna

From considerations of the exposure pathways and the distribution of radioactivity released into the environs, the applicant should estimate the maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna. Values of bioaccumulation factors used in preparing the estimates should be based on site-specific data if available; otherwise, values from the literature may be used. Tabulate and reference the values of bioaccumulation factors used in these calculations.

7.4 Nonradiological Effects

In this section, the specific concentrations of nonradioactive wastes in effluents at the points of discharge should be compared with natural ambient concentrations without the discharge and should also be compared with applicable standards. The projected effects of the effluents for both acute and chronic exposure of the biota (including any long-term buildup in soils and sediments and in the biota) should be identified and discussed. Dilution and mixing of discharges into the receiving environs should be discussed in detail, and estimates of concentrations at various distances from the point of discharge should be provided. The effects on terrestrial and aquatic environments from chemical wastes that contaminate ground water should be included.

Also discuss any potential effects of the proposed operation that do not clearly fall under any specific topic delineated above. These may include changes in land and water use at the project site; sanitary and other recovery plant waste systems; interaction of the facility with other existing or projected neighboring facilities; effects of ground-water withdrawal on ground-water resources in the vicinity of the well field(s) and recovery plant(s); effects of construction and operation of roads, transmission corridors, railroads, etc.; effects of changes in surface-water availability on biotic populations; and disposal of solid and liquid wastes other than those already discussed.

7.5 Effects of Accidents

Discuss the environmental effects of possible accidents that may occur, whether or not those accidents may produce an impact on the site or its environs. Analyses should be based on relevant experience and accident statistics from similar operating facilities. Accidents due to both human causes and natural phenomena should be addressed. See §§ 20.403 and 20.405 of 10 CFR Part 20 regarding reporting requirements.

7.5.1 Accidents Involving Radioactivity

The applicant should provide realistic analyses of accidents involving radioactivity for a spectrum of accidents that might occur ranging in severity from trivial (essentially no release of radioactivity to the environment) to large releases. Each class within the spectrum should be characterized by an occurrence rate or probability and its potential consequences, if any. Examples of accidents resulting in large releases would be an undetected lixiviant excursion or the failure of a waste retention system resulting from an act of nature, faulty design, or misoperation. Examples of accidents resulting in small releases would be failure of a pumping circuit with ground surface lixiviant release or failure of the ventilation system serving the chemical makeup area. An example of a trivial accident would be the leakage of a vessel containing barren lixiviant solution. Also describe measures to be taken to prevent accidents, and provide a discussion of proposed contingency plans to be implemented in the event that accidents occur.

7.5.2 Transportation Accidents

The potential environmental effects from transportation accidents involving radioactive and other hazardous materials should be evaluated.

7.5.3 Other Accidents

In addition to accidents that could release radioactivity to the environs, there might be accidents that, although radioactive materials would not be involved, would have consequences that could affect the environment. Such accidents as chemical explosions or fires, steam boiler failures, and leakage or rupture of vessels containing toxic materials could have significant environmental impacts. These possible accidents and associated effects should be identified and evaluated.

7.6 Economic and Social Effects of Construction and Operation

The purpose of this section is to provide guidance on the information needed to assess the economic and social effects of the proposed operations. There are, of course, limitations on the extent to which the social and economic benefits and costs of a project can be evaluated. The wide variety of benefits and costs are not only difficult to assess, but many are not amenable to quantification or even to estimation in commensurable units. Some primary benefits such as the quantity of uranium recovered are, to a degree, measurable as are the capital costs and operating and maintenance costs of the proposed facility. On the other hand, numerous environmental costs and their economic and social consequences are not readily quantifiable. All potential significant social and economic benefits and costs should be addressed in the application and, to the extent possible, should be discussed in quantitative terms.

Based on past reviews of research and development operations, the economic and social effects of construction and operation are usually minimal. However, the applicant should consider these to determine if there are any unique circumstances that could result in significant economic or social effects.

7.6.1 Benefits

The primary benefits of the proposed facility are those inherent in the value of the uranium to be recovered and the kilowatt-hours of electricity the uranium represents.

There are other social and economic benefits that affect various political jurisdictions or interests to a greater or lesser degree. Some of these reflect transfer payments or other values that may partially, if not fully, compensate for certain services as well as external or environmental costs, and this fact should be reflected in the designation of the benefit. Some examples are:

- Tax revenues to be received by local, State, and Federal governments.
- Temporary and permanent new jobs created and payroll (value-added concept).
- Incremental increase in regional product.
- Enhancement of recreational values.
- Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats.
- Creation and improvement of local roads, waterways, or other transportation facilities.
- Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with

plant operation and technological improvements from the applicant's research programs.

Discuss significant benefits that may be realized from construction and operation of the proposed facility. Where the benefits can be expressed in monetary terms, they should be discounted to present worth. In each instance where a particular benefit is discussed, the applicant should indicate, to the extent practical, who is likely to be affected and for how long. In the case of esthetic impacts that are difficult to quantify, the applicant should provide pictorial drawings of structures or environmental modifications visible to the public.

7.6.2 Costs

The economic and social costs resulting from the proposed operations are complex and need to be appraised.

The primary internal costs are (1) the capital costs of land acquisition and improvement, (2) the capital costs of facility construction, (3) other operating and maintenance costs, including license fees and taxes, (4) groundwater-quality restoration, surface reclamation, and plant decommissioning, and (5) research and development costs, including postoperational monitoring requirements. As in the case of benefits, the applicant should discount these costs to present worth.

There are also external costs. Their effects on the interests of people need to be examined. The applicant should supply, as applicable, an evaluation, including supporting data and rationale, regarding such external social and economic costs. For each cost, the applicant should describe the probable number and location of the population group adversely affected, the estimated economic and social impact, and any special measures to be taken to alleviate the impact.

Temporary external costs include housing shortages; inflationary rentals or prices; congestion of local streets and highways; noise and temporary esthetic disturbances; overloading of water supply and sewage treatment facilities; crowding of local schools, hospitals, or other public facilities; overtaxing of community services; and disruption of people's lives or of the local community caused by acquisition of land for the proposed site.

Long-term external costs include impairment of recreational values (e.g., reduced availability of desired species of wildlife and sport animals, restrictions on access to land or water areas preferred for recreational use); deterioration of esthetic and scenic values; restrictions on access to areas of scenic, historic, or cultural interest; degradation of areas having historic, cultural, natural, or archeological value; removal of land from present or contemplated alternative uses; reduction of regional products because of displacement of persons from the land proposed for the site; lost income from recreation or tourism that may be impaired by environmental disturbances; lost income attributable to environmental degradation; decrease in real estate values in areas adjacent to the proposed facility; and increased costs to local governments for the services required by the permanently employed workers and their families. In discussing the costs, the applicant should indicate, to the extent practical, who is likely to be affected and for how long.

7.6.3 Resources Committed

Any irreversible and irretrievable commitments of resources due to the operation should be discussed. This discussion should include both direct commitments such as depletion of uranium resources and irreversible environmental losses such as destruction of wildlife habitat.

In this discussion, the applicant should consider lost resources from the viewpoints of both relative impacts and long-term net effects. As an example of relative impact assessment, the loss of a few animals of a given species could represent quite different degrees of significance, depending on the total population in the immediate region. Such a loss in the case of a small local population, however, could be less serious if the same species were abundant in neighboring regions. Similarly, the loss of a given area of highly desirable land should be evaluated in terms of the total amount of such land in the environs. These relative assessments should accordingly include statements expressed in percentage terms in which the amount of expected resource loss is related to the total resource in the immediate region and in which the total in the immediate region is related to that in surrounding regions. The latter should be specified in terms of areas and distances from the site.

8. ALTERNATIVES TO PROPOSED ACTION

In this chapter, the applicant's choice of the particular mining and recovery processes for the ore body must be supported through a comparative evaluation of available alternatives. To the extent possible, discuss realistic alternatives for the various processing stages. Discussion of alternatives should include a description of the ground-water-quality restoration program to be applied for each alternative. The NRC will consider all those alternatives that may reduce or avoid significant adverse environmental, social, and economic effects expected to result from construction and operation of the proposed activity. The NRC will not preselect the alternatives that should be considered by the applicant; rather, the applicant should make this determination for this specific case and should also make clear the bases and rationales for the choices in regard to number, availability, suitability, and factors limiting the range of alternatives that might avoid some or all of the environmental effects identified in Chapter 7, "Environmental Effects." For commercial-scale operations, the comparative evaluation of available alternatives should include results obtained from research and development operations.

In the discussion of waste management alternatives, consideration should be given to the following siting, design, and operational performance objectives developed by the NRC staff in addition to the plans for final disposal discussed in Chapter 6, "Ground-Water-Quality Restoration, Surface Reclamation, and Plant Decommissioning."

1. Locate the liquid impoundment area(s) at sites where disruption and dispersion by natural forces are eliminated or reduced to the maximum extent reasonably achievable.

2. Design the impoundment area(s) so that seepage of toxic materials into the ground-water system would be eliminated or reduced to the maximum extent reasonably achievable.

9. BENEFIT-COST ANALYSIS

In this chapter, the applicant's benefit-cost statement should be summarized. The presentation should be made in the form of a narrative with accompanying tables and charts. It should clearly discuss the important benefits and costs of the proposed operations to justify the issuance of the license.

The applicant will have to develop criteria for assessing and comparing benefits and costs where these are expressed in nonmonetary or qualitative terms. The rationales for the selection of process alternatives as well as subsystem alternatives should be presented. In any case, the applicant should describe potential cumulative effects and should discuss in detail the tradeoffs that were made in order to warrant licensing of the proposed operation. The rationale for omitting apparent benefits or costs from the applicant's analysis should be explained. Key all the terms used in the benefit-cost analysis to the relevant sections of the application.

10. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

List all licenses, permits, and other approvals of construction and operations required by Federal, State, local, and regional authorities for the protection of the environment.* List those Federal and State approvals that have already been received, and indicate the status of pending approvals. For general background, submit similar information regarding approvals, licenses, and contacts with local authorities. Indicate whether or not an environmental assessment or a full environmental impact statement has ever previously been prepared for the proposed mining site area or surrounding area. If so, cite the document.

Discuss the status of efforts to obtain a water-quality certification under Section 401 and discharge permits under Section 402 of the Federal Water Pollution Control Act, as amended, if required. If not already obtained, indicate when certification is expected. If certification is not required, explain.

In view of the potential effects of a proposed commercial-scale operation on the economic development of the region in which it would be located, the applicant should also note the State, local, and regional planning authorities contacted or consulted. Office of Management and Budget Circular A-95** identifies the State, metropolitan, and regional clearinghouse that should be contacted, as appropriate.

Describe meetings held with environmental and other citizen groups with references to specific instances of the applicant's compliance with citizen group recommendations.

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*This list should be updated bimonthly until final action is taken by the NRC.

**Copies of this circular are available from the Office of Management and Budget, Washington, D.C. 20503.

11. REFERENCES

The applicant should provide a bibliography of all sources used in preparing the application. References cited should be keyed to the specific sections and page numbers to which they apply. The applicant should also list the names, together with their qualifications (expertise, experience, professional disciplines), of the persons who were primarily responsible for preparing the application.

APPENDIX A

INFORMATION NEEDED BY NRC STAFF TO PERFORM RADIOLOGICAL IMPACT EVALUATIONS FOR COMMERCIAL-SCALE IN SITU URANIUM SOLUTION MINING FACILITIES

1. Detailed site plot plan (overlaid on topographic map, with scale and true north arrow) clearly identifying all locations of:

    a. Site property boundaries

    b. Restricted area boundaries, if different from site property boundaries

    c. All radiological effluent release points (or areas) such as

        (1) Production wells

        (2) Yellowcake drying and packaging area emission stacks or vents (if applicable)

        (3) Evaporation, settling, or any other solid/liquid disposal pond areas

        (4) Any other release points of emission to the atmosphere, e.g., surge tanks, process building vents

    d. Lands owned, leased, or otherwise controlled (including mill site claims) by the applicant

    e. Lands usable and available for grazing

    f. Private residences or other structures used by the general public

    g. Vegetable or other crops, identified by type and growing season

    h. Milk animals (cows or goats)

2. Locations of sources and receptors

    All locations should be given in terms of distances from a central release point. Coordinates relative to this release point should be given as follows:

    a. x kilometers east of the central release point

    b y kilometers north of the central release point

    c. z meters elevation from the base of the central release point

    (Note: Locations to the south and/or west should be denoted by a negative value. Any recognizable facility will suffice as a central frame of reference.)

Table 1 lists the types of sources and receptors and the format suggested for reporting the locations requested.

Table 1

Sources		East (km)	North (km)	Elevation (m)
1.	Yellowcake dryer	0	0	--
2.	Center of ore bodies (at ground surface level)	--	--	--
3.	Solid/liquid disposal areas	--	--	--
4.	Production wells	--	--	--
5.	Other sources, if applicable	--	--	--
Receptors				
1.	Nearest resident	--	--	--
2.	Nearest resident in prevailing wind direction	--	--	--
3.	Ranch	--	--	--
4.	Farm	--	--	--
5.	Orchard	--	--	--
6.	Grazing location 1	--	--	--
7.	Grazing location 2	--	--	--
4.	Garden	--	--	--
5.	Ranger bunk house	--	--	--
6.	Mine camp	--	--	--
7.	Town 1	--	--	--
8.	Town 2	--	--	--
9.	City 1	--	--	--
10.	Other nearby residents, industrial (or recreational) facilities	--	--	--
11.	Restricted area boundaries (N, S, E, W, NE, SW, SE, NW)	--	--	--

3. Time-sequenced bar graph describing various stages of the facility's operational and postoperational life. This should include any alterations relating to the sources of emission such as source location, operation, restoration, termination. Changes in exposed areas in evaporation ponds should also be indicated.

4. The following parameter values should be provided (if there are changes in Part 3 above, multiple corresponding values for each stage should be reflected here):

Parameter	Value
Average ore quality, U_3O_8, in ore body	________ %
Ore activity, U-238, U-234, Th-230, Ra-226, and Pb-210	________ pCi/g
Operating days per year (plant factor)	________ days
Dimensions of the ore body or bodies	
· Acres per year to be mined	________ acres
· Average thickness of body (bodies)	________ meters
Average production flow rate	________ gpm
Formation porosity	________ %
Process recovery	________ %
Leaching efficiency	________ %
Rock density	________ g/cm^3
Restoration flow rate	________ gpm
Production cell parameters	
Residence time	________ days
Type of cell pattern (5, 7 spot, or other)	________
Radius	________ m
Average cell flow rate	________ gpm
Annual Rn-222 emission from production	________ Ci/yr
Annual Rn-222 emission from restoration	________ Ci/yr

(Note: If the Rn-222 is not measured, indicate the complete calculational methodology, providing all assumed parameter values and references.)

Yellowcake drying and packaging data (if applicable)

Processing rates for drying and packaging if different ______________MT/hr

Estimated annual yellowcake production rate ______________MT/yr

Expected yellowcake purity, U_3O_8 by weight ______________%

Any measured airborne effluent concentrations

______________Ci U-238/yr

______________Ci Th-230/yr

______________Ci Ra-226/yr

______________Ci Pb-210/yr

Stack heights and airflows

Drying______________m, m^3/s

Packaging____________m, m^3/s

Other______________m, m^3/s

Anticipated release rates for dryer stack, the packaging area ventilation exhaust, and any yellowcake storage area ventilation exhausts

Dryer Stack__________kg/hr

Packaging Stack______kg/hr

Other______________kg/hr

Drying and packaging operations are carried out ______________hr/d and d/yr

Description of all ventilation air filtration equipment with design, expected, and minimum efficiencies (if applicable) (Attach sheet)

Filtration equipment testing procedures and frequencies (Attach sheet)

Solid/liquid disposal impoundments, e.g., evaporation ponds (Attach sheet)

Complete physical, chemical, hydrological, and radiological description of disposal impoundment system.

Total area of each impoundment area and surface areas expected to be under water, saturated, moist, and dry (indicate surface moisture contents used as basis of estimates).

Anticipated Rn-222 release rates for surface areas under water, saturated, moist, and dry, Ci/yr per m^2.

If not included above, please provide the following:

Total dissolved solids in liquid waste ________________ g/l

Activity of solids in impoundments ________________ pCi U-238/g

________________ pCi Th-230/g

________________ pCi Ra-226/g

________________ pCi Pb-210/g

Activity in liquids in impoundments ________________ pCi U-238/l

________________ pCi Th-230/l

________________ pCi Ra-226/l

________________ pCi Pb-210/l

Density of solids ________________ g/cm^3

5. Meteorological Data

Annual joint relative frequency distributions of wind direction and wind speed by atmospheric stability class (see Table 2 on page 3.46-37).

a. Wind direction to be given in the 16 compass directions.

b. Wind speed to be given in knots in the indicated classes (i.e., 0-3, 4-6, 7-10, 11-16, 17-21, over 21)

c. Atmospheric stability to be given in the following manner:

A - Extremely unstable

B - Moderately unstable

C - Slightly unstable

D - Neutral

E - Moderately stable

F - Very stable

Further information is available in Regulatory Guide 1.23 (Safety Guide 23), "Onsite Meteorological Programs." For each atmospheric stability class, provide the data in the format indicated in Table 2.

Table 2

Stability Class Wind Direction	Wind Speed Class (knots) 0-3	4-6	7-10	11-16	17-21	Over 21
N						
NNE						
NE						
ENE						
E						
ESE						
SE						
SSE						
S						
SSW						
SW						
WSW						
W						
WNW						
NW						
NNW						

d. Regional Data (Within 80 km) (Attach sheet)

(1) Population distributions by direction (12) and radius (1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km) for a recent year (no earlier than 1970) and for the last year of expected operations (see Table 3 on page 3.46-39 for reporting table format).

(2) Available county food production data, in kg/yr, for vegetables (by type and totals), meat (all types), and milk; if available, include any future predictions by local governmental or industrial or institutional organizations.

6. Miscellaneous

If not included above, please provide:

Fraction of year during which cattle graze locally ______________%

Fraction of cattle feed obtained by grazing ______________%

Fraction of stored cattle feed grown locally ______________%

Acreage required to graze 1 animal unit (450 kg) for one month (AUM) ________________ha

Length of growing season ________________mo/yr

Fraction of locally produced vegetables consumed locally ________________%

Fraction of locally produced meat consumed locally ________________%

Fraction of locally produced milk consumed locally ________________%

Table 3

	Population Distribution															
Kilometers	N 0.0	NNE 22.5	NE 45.0	ENE 67.5	E 90.0	ESE 112.5	SE 135.0	SSE 157.5	S 180.0	SSW 202.5	SW 225.0	WSW 247.5	W 270.0	WNW 292.5	NW 315.0	NNW 337.5
1.0- 2.0																
2.0- 3.0																
3.0- 4.0																
4.0- 5.0																
5.0-10.0																
10.0-20.0																
20.0-30.0																
30.0-40.0																
40.0-50.0																
50.0-60.0																
60.0-70.0																
70.0-80.0																

VALUE/IMPACT STATEMENT

An NRC source and byproduct material license is required in order to process uranium solutions extracted from in situ uranium solution mining operations. General guidance for filing an application is provided in § 40.31 of 10 CFR Part 40, "Domestic Licensing of Source Material." Regulatory Guide 3.46 (Task FP 818-4) provides specific guidance on the format and content of applications, including environmental reports, for licenses to authorize in situ uranium solution mining operations. The guide conforms to NRC regulations and reflects experience gained over the past several years in actual licensing cases.

Basic detailed guidance is essential to applicants for the efficient preparation of applications, including environmental reports, for in situ uranium solution mining facility licenses and for their review by the NRC staff. Such detailed guidance is not presently delineated in NRC regulations or in regulatory guides. Based on experience gained in the issuance of such licenses, the NRC staff has identified information that should be contained in applications, including environmental reports, to reflect present needs and practices. Such information provided in a regulatory guide will be helpful to both applicants and the NRC staff in reducing the cost and time involved in preparing and processing license applications. It should result in a significant reduction in the number of questions and requests for clarification submitted by the NRC staff to applicants, should improve the consistency in application reviews because of more uniform application submittals, should reduce the amount of NRC staff review effort in license processing, and should expedite licensing actions.

6-2/3.50

U.S. NUCLEAR REGULATORY COMMISSION January 1982

REGULATORY GUIDE

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(Task FP 907-4)

GUIDANCE ON PREPARING A LICENSE APPLICATION TO STORE SPENT FUEL IN AN INDEPENDENT SPENT FUEL STORAGE INSTALLATION

INTRODUCTION

Subpart B, "License Application, Form, and Contents," of 10 CFR Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation," specifies the information to be covered in an application for a license to store spent fuel in an independent spent fuel storage installation (ISFSI). However, Part 72 does not specify the format to be followed in the license application. This regulatory guide suggests a format acceptable to the NRC staff for submitting the information specified in Part 72 for a license application to store spent fuel in an ISFSI.

Other regulations applicable to the licensing of spent fuel storage in an ISFSI are in the following parts of Title 10, "Energy," of the Code of Federal Regulations:

2 - Rules of Practice for Domestic Licensing Proceedings
8 - Interpretations
9 - Public Records
11 - Criteria and Procedures for Determining Eligibility for Access to or Control over Special Nuclear Material
19 - Notices, Instructions and Reports to Workers; Inspections
20 - Standards for Protection against Radiation
21 - Reporting of Defects and Noncompliance
25 - Access Authorization for Licensee Personnel
51 - Licensing and Regulatory Policy and Procedures for Environmental Protection
73 - Physical Protection of Plants and Materials
75 - Safeguards on Nuclear Material–Implementation of US/IAEA Agreement
95 - Security Facility Approval and Safeguarding of National Security Information and Restricted Data
150 - Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters under Section 274
170 - Fees for Facilities and Materials Licenses and other Regulatory Services under the Atomic Energy Act of 1954, as Amended.

Part 72 provides for a single licensing procedure. The smooth functioning of this one-step licensing procedure requires that the license application be essentially complete in its initial submission. A license under this part will be issued before the start of construction of any physical facilities involved. Under this procedure, the final design details of those ISFSI components, systems, and structures that are important to safety must be available for review and evaluation. Part 72 also requires that a site evaluation be provided to ensure that the natural characteristics of the site and its environs are sufficiently known and have been factored into the engineering design of the installation. The document in which this information is presented is a Safety Analysis Report (SAR).

Although an applicant may plan to contract with another organization for the design, construction, and possibly the operation of the proposed ISFSI, a licensee under Part 72 cannot delegate to a contractor the responsibility for meeting all applicable regulatory requirements. This means that the applicant must make a commitment that, as the licensee, it will have an adequate staff to ensure that regulatory requirements are met at each stage of the proposed project. If the applicant plans to contract with another organization for the operation of the proposed ISFSI, the contractual arrangements must be described in the license application. Any subsequent changes in such contractual arrangements may require an amendment to the license.

This guide represents a standard format that is acceptable to the NRC staff for the license application. Conformance with this guide, however, is not mandatory. License applications with different formats will be acceptable to the staff if they provide an adequate basis for the findings required for the issuance of a license. However, because it may be

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USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

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more difficult to locate needed information, the staff review time may be longer, and there is a greater likelihood that the staff may regard the license application as incomplete.

As experience is gained in the licensing of spent fuel storage, the Commission's requirements for information needed in its review of applications for licenses to store spent fuel in an ISFSI may change. Revisions of the Commission's needs for information in connection with such licensing actions will be conveyed to the industry and the public by (1) amendments to NRC regulations, (2) revisions to this regulatory guide, (3) issuance of new or revised regulatory guides, and (4) direct communications, as needed, with an applicant by the NRC staff.

Since the preparation of a license application pursuant to Part 72 will be a new experience, prospective applicants are encouraged to meet with representatives of the Division of Fuel Cycle and Material Safety of the Office of Nuclear Material Safety and Safeguards during the development of a license application to resolve any problems that may arise. An early resolution of potential problems is beneficial to all concerned with the licensing process.

Contents of the License Application

The license application is the basic document that must address each of the requirements of Part 72 and must be complete in itself. However, the following subjects should be covered in separate reports that are identified as enclosures to the license application, and the contents of each report should be summarized in a brief statement in the license application:

1. Safety Analysis Report
2. Decommissioning Plan
3. Emergency Plan
4. Environmental Report
5. Quality Assurance Program
6. Physical Security Plan
7. Safeguards Contingency Plan
8. Personnel Training Program
9. Proposed License Conditions, including Technical Specifications
10. Design for Physical Security

Format and Style

The applicant should strive for clear, concise presentation of the information provided in the application. The application should be written in plain English and should be understandable to an educated lay person.

Abbreviations should be consistent throughout the license application and its enclosures. Any abbreviations, symbols, or special terms unique to the proposed activity or not in general use should be defined when they first appear.

A title page identifying key individuals responsible for the preparation of the license application and the oath required under paragraph 72.11(b) should be included. A table of contents should also be included.

Physical Specifications

1. Paper size: 8½ x 11 inches

2. Paper stock and ink: Suitable quality in substance, paper color, and ink density for handling and reproduction by microfilming or image-copying equipment.

3. Paper margins: A margin of no less than 1 inch should be maintained on the top, bottom, and binding side of all pages.

4. Printing:

   a. Composition: Text should be single or 1½ spaced.

   b. Type face and style: Suitable for microfilming or image-copying equipment.

   c. Reproduction: Either mechanical or photographic. Text should be printed on both sides of the paper with the image printed head to head.

5. Binding: Pages should be punched for a standard 3-hole loose-leaf binder.

6. Chapter and page numbering: Each requirement of the regulation addressed should be shown as a separate chapter with the same number as the chapter given in this guide, e.g., Chapter 8, "Operator Training." Pages should be numbered sequentially in each chapter, e.g., 8-1, 8-2, etc. Do not number the entire document sequentially.

Procedures for Updating or Revising Pages

All pages submitted to update, revise, or add to the license application should show the date of change and a change or amendment number. The changed or revised portion of each page should be highlighted by a "change indicator" mark consisting of a bold vertical line drawn in the margin opposite the binding side.

Referenced Materials

Caution should be used in references to information previously filed with the AEC or NRC. Such references must be pertinent to the subject discussed, must contain current information, and must be readily obtainable or extractable from the referenced documents. It may be more efficient in some cases to repeat in a license application previously furnished information.

Chapter 1. GENERAL AND FINANCIAL INFORMATION

The license application should address the requirements of § 72.14 of 10 CFR Part 72 regarding details on the identity of an applicant. If the applicant is other than the owner or planned operator of the proposed ISFSI, details of the working and contractual arrangements between all parties involved should be set forth. Any information on such matters considered as proprietary information by the applicant should be identified and submitted under separate cover. The procedures in 10 CFR 2.790(b) should be followed.

If the proposed ISFSI is to be built on the site of another licensed activity or facility such as a nuclear power plant, details of the working arrangements and responsibilities of the licensees involved should be stated. Similarly, if unlicensed activities are carried out at the proposed site, any potential interactions between the proposed ISFSI and these other site activities should be explained.

Paragraph 72.14(e) specifically addresses the required financial information that must be submitted with the application. If the applicant is a government agency or a regulated utility, the assumption is made that the applicant is financially qualified for a license under Part 72. If the applicant is a corporation organized for the specific purpose of owning and operating the proposed ISFSI, details of its organizational structure, including the responsibilities of its members to meet the financial requirements of the proposed ISFSI throughout its proposed operating life and ultimate decommissioning, must be stated. This requirement is applicable even if the proposed ISFSI is to be owned and operated by a consortium of utilities.

Chapter 2. TECHNICAL QUALIFICATIONS

Paragraph 72.31(a)(4) and § 72.17 require a finding by the staff that the applicant is qualified by training and experience to construct and operate an ISFSI.

Although spent fuel storage in an ISFSI is generally considered a relatively low-risk operation compared to some other types of nuclear activities, the design, construction, and operation of an ISFSI require certain skills and an understanding of the requirements involved to ensure that the objective of a relatively low-risk operation is achieved in practice. The license application should contain a commitment that the applicant will staff the project with an adequate cadre of personnel possessing the required skills throughout all phases of the project. This element of the license application is in addition to the discussion of the conduct of operations covered in Chapter 9 of the SAR.

The licensee is responsible for the execution of the proposed project as described in the license application. This means that, even though much of the actual work involved during the site selection, design, procurement, construction, and even the operating phases of the project may be performed by a contractor, the licensee must have a staff that is knowledgeable in all aspects of the project. If such a staff does not actually exist, the applicant should describe the staffing plans in sufficient detail to support the finding required by paragraph 72.31(a)(4).

Chapter 3. TECHNICAL INFORMATION; SAFETY ANALYSIS REPORT

As required by § 72.15, the technical information is presented in the SAR, which should be submitted as an enclosure to the license application. A summary statement identifying the type of installation proposed (e.g., a water basin), its design capacity, any unique features incorporated in its design, and its mode of operation is adequate for the license application document.

The SAR required for an ISFSI differs from the SARs for some other nuclear facilities in that the initial SAR is expected to be complete and comparable in scope and detail to the final SAR for facilities licensed under 10 CFR Part 50. Section 72.15 identifies the minimum information that is required to be included in the SAR. Although § 72.50 provides for the subsequent updating of the SAR, such changes during the design and construction phases of the project are expected to be of minor importance. Any of these changes deemed significant by the staff may cause delay in the granting of the final clearance to receive spent fuel.

Guidance on the preparation of the SAR for an ISFSI of the conventional water-basin type is contained in Regulatory Guide 3.44, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Water-Basin Type)." For the dry storage ISFSI, guidance on the preparation of the SAR is contained in Regulatory Guide 3.48, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Dry Storage)."

Chapter 4. CONFORMITY TO GENERAL DESIGN CRITERIA

Subpart F of 10 CFR Part 72 contains the general design criteria for an ISFSI. The subject of conformity to the general design criteria is covered in detail in the SAR. It is sufficient that the license application contain a summary discussion of each criterion and reference where more detailed information on a specific subject can be found in the SAR.

Chapter 5. OPERATING PROCEDURES; ADMINISTRATIVE AND MANAGEMENT CONTROLS

Paragraph 72.31(a)(5) requires a finding by the staff that the applicant's proposed operating procedures to protect health and to minimize danger to life or property are adequate. Essential to these operating procedures are the applicant's proposed administrative and management controls. Guidance on this subject is available in ANSI N299-1976, "Administrative and Managerial Control for the Operation of Nuclear Fuel Reprocessing Plants."* Although ANSI N299-1976 is designed for the much more complex operating requirements of a fuel reprocessing plant, the basic principles set forth for administrative and managerial controls are considered applicable to the operation of an ISFSI. Paragraph 72.15(a)(8) identifies the information that is to be included in the SAR.

If the proposed ISFSI is to be operated by the owner, a relatively brief explanation of how the requirements of ANSI N299-1976 will be met may be adequate. However, if the proposed ISFSI is to be operated by a contractor, considerable detail will be required on the working arrangements between the parties involved. Particular attention should be placed on the description of the administration of the Independent Review and Audit Program that is identified in ANSI N299-1976.

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*Copies may be obtained from the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.

Chapter 6. QUALITY ASSURANCE PROGRAM

The quality assurance program required by § 72.80 must be submitted as an enclosure to the application and is briefly discussed in Chapter 11 of the SAR. It is sufficient that the license application contain a commitment that the quality assurance program described is (or will be) understood by all involved in its execution and that the program will be implemented, as applicable, for all phases of the project, including any activities important to safety that have been carried out prior to submission of the license application.

This program should cover the engineering aspects of the site investigation, facility design, procurement, shop fabrication, onsite construction, preoperational testing, conduct of operations, and ultimate decommissioning. The emphasis of this program should be on those activities and items that are identified as being important to safety. The planned quality assurance effort should be commensurate with the importance to safety of such identified activities and items.

Chapter 7. OPERATOR TRAINING

ISFSI operators are not required to be licensed. However, they must have a level of qualifications and training in subjects and operating procedures applicable to the operation of an ISFSI comparable to the requirements of 10 CFR Part 55 on spent fuel pool operation for licensed operators of a reprocessing plant or nuclear power plant. Appropriate documentation of training activities and certifications of proficiency should be included in the ISFSI records. Subpart I, "Training and Certification of ISFSI Personnel," of 10 CFR Part 72 requires that a training program be established and that the personnel training program document be included as an enclosure to the license application. A brief summary of the program should be included in the application.

In addition to the specific operating requirements of the planned facility, the training program should also cover the nuclear engineering principles involved in the safe handling and storage of spent fuel and the regulations, regulatory guides, and national standards applicable to ISFSI operations. Guidance on the content of the required training program is available from the Fuel and Spent Fuel Licensing Branch, Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Chapter 8. INVENTORY AND RECORDS REQUIREMENTS

A description of the inventory and records system for the stored fuel should be included in the license application. Section 72.51 identifies the inventory and record requirements for spent fuel stored at an ISFSI. Because of the uncertainty as to the ultimate disposition of spent fuel stored in an ISFSI, the records on the identity of each fuel assembly should be complete. As a minimum, these records should cover:

a. Fuel manufacturer,
b. Date of manufacture,
c. Reactor exposure history,
d. Burnup,
e. Pertinent observations on discharge and during storage at the reactor, transfer to the ISFSI, and storage in the ISFSI.

If storage of consolidated fuel rods is being considered, special requirements concerning inventory and recordkeeping for stored fuel pins should be described.

Chapter 9. PHYSICAL PROTECTION

Subpart H, "Physical Protection," of 10 CFR Part 72 requires that a physical security plan (§ 72.81), a design for physical protection (§ 72.82), and a safeguards contingency plan (§ 72.83) be submitted. Since the details of the provisions for physical protection are withheld from public disclosure, this subject should be covered in separate reports. The license application should contain only a reference to the identity of the reports and when they were submitted.

Interim guidance regarding the proposed design for physical security and the format and content of the physical security plan can be obtained from the Director, Division of Safeguards, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Guidance for the safeguards contingency plan is contained in Regulatory Guide 5.55, "Standard Format and Content of Safeguards Contingency Plans for Fuel Cycle Facilities."

Chapter 10. DECOMMISSIONING PLAN

Section 72.18 requires the submission of a decommissioning plan as part of the license application. A brief description of the decommissioning plan is included in Section 9.6 of the SAR. The license application need contain only a brief summary statement, enough to identify what will be involved and the basis for the estimated costs of decommissioning.

However, the financial provisions for carrying out the decommissioning plan at the end of useful life of the proposed ISFSI are not necessarily addressed in the SAR and must be covered in either the license application or the decommissioning plan.

Chapter 11. EMERGENCY PLAN

Section 72.19 requires that an emergency plan be provided as part of the license application. The plan must include the information listed in Section IV, "Content of Emergency Plans," of Appendix E to 10 CFR Part 50.

Chapter 12. ENVIRONMENTAL REPORT

Section 72.20 requires that an environmental report be provided as part of the license application. Guidance on the format and content of an environmental report for an ISFSI may be found in 10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection."

In the interests of keeping the size of this report within reasonable bounds and its structure and language keyed to the general public, it is recommended that a prospective applicant confer with the NRC staff to obtain definitive guidance on the scope and content of this report.

Chapter 13. PROPOSED LICENSE CONDITIONS

License conditions proposed by an applicant constitute a commitment by the applicant to take the actions specified therein. Because a license issued pursuant to Part 72 is issued prior to the commencement of construction, license conditions cover the entire proposed life of the ISFSI, from site selection through the subsequent phases of design, construction, operation, and ultimate decommissioning.

License conditions can be considered in two broad categories: (1) administrative and management organization and controls and (2) technical specifications. Those addressing administrative and management subjects should be covered in the license application; those addressing technical subjects can be covered very briefly in the license application with appropriate references to Chapter 10 of the SAR. Care should be taken to ensure that such references are clear and explicit.

Proposed license conditions should address such subjects as:

1. Administrative and management organization; procedures and controls, including review and approval activities; and auditing and reporting requirements. In particular, the subject of interfaces between the licensee and its contractors should be covered.

2. Verification of design features that are important to safety. In particular, those quality assurance activities that confirm that design and construction are being carried out in accordance with plans, e.g., inspection hold points, should be covered.

3. Test procedures throughout the life of the project. Such subjects as conditions applicable to site evaluation, component testing during design and construction, preoperational testing prior to startup, and conditions applicable to tests that may be desirable after the commencement of operations should be covered.

4. Functional and operating limits of monitoring instruments and limiting control settings.

5. Limiting conditions of operation. The functional capabilities or performance levels of equipment and systems that are important to safety should be addressed. The subject includes setpoint limits on monitoring instruments and any controls that may need to be imposed on personnel access to any part of the installation.

6. Surveillance requirements. Such items as the periodic inspection of cranes and, for water pools, water purity and evidence of corrosion should be covered.

VALUE/IMPACT STATEMENT

1. ACTION

1.1 Description

This guide is an updating of the material in Regulatory Guide 3.24 to correct omissions and reflect regulatory developments since Regulatory Guide 3.24 was issued. Regulatory Guide 3.24 was withdrawn on February 27, 1981 (46 FR 14507).

1.2 Need

There is increasing interest in the nuclear community in the licensing requirements for the storage of spent fuel in an ISFSI. The guide is designed to assist prospective applicants by discussing in more detail specific requirements of Part 72 for the license application.

1.3 Value/Impact

1.3.1 NRC

The further explanation of the content of license applications covering the storage of spent fuel in an ISFSI will be helpful to the licensing staff in their contacts with potential licensees and in the review of these applications when received, particularly during the "mini-review" before docketing of such applications.

1.3.2 Other Government Agencies

The Tennessee Valley Authority has expressed interest in the storage of spent fuel in an ISFSI and is now trying to determine the applicable licensing requirements.

1.3.3 Industry

The further explanation of the content of license applications covering the storage of spent fuel in an ISFSI is thought to be particularly useful to the utilities, which deal primarily with the NRC Office of Nuclear Reactor Regulation and which now will be dealing with the NRC Office of Nuclear Material Safety and Safeguards, which handles the licensing of spent fuel storage in an ISFSI and operates somewhat differently.

1.3.4 Public

There is a need to aid the public in becoming better informed on the various aspects of the licensing of spent fuel storage in an ISFSI. The guide will contribute to meeting this need.

2. TECHNICAL APPROACH

The guide is nontechnical in its content.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

The following are potential NRC procedures that may be used to disseminate the information contained in the guide:

- Regulation
- Regulatory guide
- Branch position paper
- NUREG-series report

3.2 Value/Impact of Procedural Alternatives

A regulation is not a suitable means of disseminating the explanatory type of information contained in the proposed guide. A NUREG-series report is also not a viable alternative because the proposed guide contains regulatory positions. Only a regulatory guide or branch position paper are considered to be viable alternatives.

Branch positions are sometimes presented for guidance of this sort. However, because of the limited distribution within NRC for concurrence, branch positions should be formalized by the issuance of a regulatory guide. In this case, no branch position has been prepared or is anticipated.

3.3 Decision on Procedural Approach

A regulatory guide should be prepared.

4. STATUTORY CONSIDERATIONS

4.1 NRC Authority

Authority for this guide is derived from the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, and implemented through the Commission's regulations.

4.2 Need for NEPA Assessment

The action is not a major Federal action as defined by 10 CFR 51(a)(10) and does not require an environmental impact statement.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

The guide is one of a series of guides that will replace Regulatory Guide 3.24. Other guides in this series include Regulatory Guide 3.44, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Water-Basin Type)"; Regulatory

Guide 3.48, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Dry Storage)"; and Regulatory Guide 3.49, "Design of an Independent Spent Fuel Storage Installation (Water-Basin Type)."

6. SUMMARY AND CONCLUSIONS

The regulatory guide should be issued to meet a current need in the written development of the regulatory bases for the licensing of spent fuel storage in an ISFSI.

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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

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REGULATORY GUIDE

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Regulatory Guide 3.51
(Task RH 802-4)

CALCULATIONAL MODELS FOR ESTIMATING RADIATION DOSES TO MAN FROM AIRBORNE RADIOACTIVE MATERIALS RESULTING FROM URANIUM MILLING OPERATIONS

USNRC REGULATORY GUIDES

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*See Table 12.

A. INTRODUCTION

The NRC staff is required to make analyses of radiation doses to the public, or individual members thereof, resulting from the radioactive effluents from uranium mills for the following purposes:

1. Evaluating compliance with 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations,"
2. Evaluating compliance with the "as low as is reasonably achievable" (ALARA) criterion embodied in 10 CFR Part 20, "Standards for Protection Against Radiation," and
3. Evaluating overall radiological impact as part of the complete environmental impact assessment required by the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190, 83 Stat. 852).

This regulatory guide describes basic features of calculational models used by the NRC staff for such evaluations and suggests values for various parameters used in the estimation of radiation doses to man from uranium milling operations. Specifically, this guide addresses the calculation of radiation doses to man from previously estimated environmental radioactivity concentrations in air. The environmental radioactivity concentrations in air required for this calculation result from extensive and detailed analyses of effluent release rates and atmospheric dispersion phenomena.

Information on the approach used for estimating source terms is included in the Final Generic Environmental Impact Statement on Uranium Milling, NUREG-0706 (Ref. 1). The methodology used by the staff for calculating atmospheric dispersion is documented in the MILDOS code user's manual, NUREG/CR-2011 (Ref. 2).

B. DISCUSSION

This guide describes models used by the NRC staff to estimate the radiological impacts resulting from uranium mills for the purpose of evaluating compliance with 40 CFR Part 190 and 10 CFR Part 20 and of assessing overall environmental radiological impacts in accordance with NEPA.

1. URANIUM MILL SOURCE TERMS

A uranium mill, unlike other types of fuel cycle facilities, goes through phases in its life cycle in which both the composition and the magnitude of its radioactive emissions (and associated impacts) vary greatly. For this reason, the NRC staff will perform impact evaluations for each individual mill at different phases of its existence. The three principal uranium mill life-cycle phases discussed in this guide are (1) operational (milling), (2) tailings pile drying and stabilization, and (3) reclamation.

Typically, a uranium mill will operate for a period of years during which there will be radon and particulate releases from the ore storage pile, the mill itself, and the tailings disposal area. During this operational period, both particulate and radon releases from the tailings pile may be somewhat curtailed by maintaining the pile at least partially under water. Mechanical sprinkler systems or chemical stabilizing agents may also be used to inhibit the suspension in air of radioactive tailings dust by the wind.

When actual milling ceases, the tailings pile is normally allowed to dry by natural evaporation until it is ready for stabilization. When the tailings are wet, there are essentially no particulate releases from the tailings pile. However, as the tailings pile dries, releases of radon and particulates from this source may increase, reaching their maximum prior to implementation of measures required to achieve long-term stabilization. After stabilization and reclamation of the tailings area, there should be no further radioactive particulate releases. However, small quantities of radon may continue to diffuse upward from the tailings and may be released to the atmosphere. These continuing radon releases, though small, are likely to persist for tens of thousands of years.

Depending on the specific details of the site, facility, effluent controls, and stabilization program, maximum individual particulate exposure could occur either during the last year of actual milling or the last year prior to stabilization of the tailings. Maximum individual doses due to radon releases are likely to occur during the last year prior to stabilization.

The radioactive isotopes comprising uranium mill radioactivity releases are mostly those belonging to the ^{238}U and ^{235}U decay series. The ^{235}U series radionuclides amount to less than 5 percent of total releases and are routinely disregarded because of their insignificant contribution to overall radiological impact.

2. CRITICAL EXPOSURE PATHWAYS

Three exposure pathways of concern for airborne releases from uranium mills are (1) inhalation of airborne radioactive material, (2) ingestion of vegetable and animal products contaminated via deposition, and (3) direct external exposure to radiation emitted by airborne activity and activity deposited on ground surfaces. Liquid exposure pathways are not usually of concern because there are usually no discharges to surface water of liquid effluents. Liquid pathways may exist, however, and methodology similar to that used in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," should be used for evaluating intakes via the liquid pathway. However, ingestion dose factors from Table 6 should be used in converting intakes to doses.

All individual exposure pathways of significance will be evaluated at locations where the exposure pathway and a dose receptor actually exist at the time the analysis is made. Also, the applicant may take into account any real phenomena or actual exposure conditions that may be present. Such conditions could include actual values for agricultural productivity, dietary habits and food sources, occupancy times, measured environmental transport factors, or similar values determined for a specific site. However, if the analysis is based on existing conditions and if potential changes in land use and food pathways could result in significantly higher exposures, the applicant should provide reasonable assurance that a monitoring and surveillance program will be performed on a regular and continuing basis to determine if such changes have occurred.

3. REQUIRED DOSE ESTIMATES

3.1 Individual Doses

Evaluations of the dose received by an exposed individual are made to satisfy the requirements of both 40 CFR Part 190 and 10 CFR Part 20. The Environmental Protection Agency (EPA) regulation, 40 CFR Part 190, speaks to individual radiation doses from all pathways and all nuclear power and fuel cycle facilities combined, except that exposure from radon and its daughters need not be included. The NRC regulation, 10 CFR Part 20, includes a requirement to keep all radiation exposures "as low as is reasonably achievable" (ALARA). ALARA is a general concept that has not to date been interpreted in the form of numerical design objectives for uranium mills as it has been for light-water-cooled nuclear reactors (see Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criteria 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"). However, a case-by-case evaluation will be made to ensure that doses are kept as low as is reasonably achievable. ALARA evaluations will address all releases, including radon and its daughters, and will consider population doses as well as individual doses.

For the purpose of evaluating compliance with 40 CFR Part 190, the whole body and organ doses to any individual for all pathways combined and from all activity releases except radon and its daughters are evaluated for (1) the last year of actual mill operation and (2) the last year prior to tailings pile reclamation. These evaluations are adequate for assessing ALARA compliance except that exposure to radon and its daughters should be included and radon and daughter exposure for the first year after tailings pile reclamation should also be evaluated. Postreclamation exposure to radon and its daughters should be evaluated at the location of greatest radon concentration where unrestricted land use after mill decommissioning may be permitted.

Exposed individuals are characterized by food consumption, occupancy, and other uses of the region in the vicinity of the mill site. All physiological and metabolic parameters for the exposed individuals are assumed to have those characteristics that represent the averages for the various age groups in the general population. Although specific individuals will almost certainly display dietary, recreational, and other living habits considerably different from those suggested here and actual physiological and metabolic parameters may vary considerably, the NRC staff considers the use of these reference values to be acceptable because the actual physiological and metabolic characteristics of specific individuals cannot usually be determined. Applicants are encouraged to use information and data applicable to a specific region or site when possible.

When site-specific information and data are used, their origin or derivation should be documented for the NRC staff's review.

In this guide, the term "dose" is used instead of the more precise term "dose equivalent." When applied to the evaluation of internal deposition of radioactivity, the term "dose," as used here, includes the prospective dose component arising from retention in the body beyond the period of environmental exposure, i.e., the committed dose equivalent. The committed dose equivalent is evaluated over a period of 50 years.

The committed dose equivalent per unit intake, either by inhalation or ingestion, usually varies by age as well as by organ. For the purpose of calculating collective (population) doses, the population has been assumed to be composed of four age groups: infants (0 to 1 year), children (1 to 11 years), teenagers (11 to 17 years), and adults (17 years and older). Four sets of ingestion-dose conversion factors are presented in this guide, one for each of these four age groups. Available data are not sufficient to permit the calculation of age-specific dose conversion factors for inhalation exposure, and adult dose conversion factors are assumed to apply for all age groups for this exposure pathway.

3.2 Population Doses

Evaluations of population doses resulting from uranium milling operations are required to satisfy NEPA requirements for assessing the total environmental impact associated with the operation of each facility. Calculated estimates of resulting population doses therefore need to reflect, insofar as practicable, the overall radiological impact of each uranium mill over the duration of its existence.

For a typical uranium mill, the total radiological impact is composed of the impacts of the three major phases of its existence: the operational phase, the prereclamation phase, and the postreclamation phase. The first two phases may involve substantial releases of radon gas and particulates but are of relatively short duration. The postreclamation phase involves only small releases of radon, but these releases may persist for periods of tens of thousands of years. For each phase, the average annual radiological impact will be estimated by the NRC staff using the following basic procedure:

1. Annual average releases over the duration of the particular mill phase will be estimated for each radionuclide.

2. The radiological impact resulting from 1 year of average releases will be evaluated in terms of population dose using the EPA concept of "environmental dose commitment" (Ref. 3). The environmental dose commitment will be evaluated for a period of 100 years following release as per the procedure used by EPA in setting the standards in 40 CFR Part 190.

The total dose commitments for the operational and prereclamation phases will be calculated by multiplying the annual population dose commitments by the number of years the mill is expected to be in each phase. The sum of these two products represents an approximation of the combined radiological impact of the facility prior to tailings pile reclamation. The annual population dose commitments from postreclamation radon releases are also calculated and represent the continuously recurring impact of this residual activity source.

Consideration of particulate releases will generally be limited geographically to the area within 80 km (50 mi) of the mill site. Within this area, exposure pathways requiring assessment include all those considered in the evaluation of maximum individual exposure. Outside the 80-km (50-mi) radius, only radon and daughters require consideration and these are treated separately from particulate releases (see Regulatory Position 3.2).

4. USE OF THIS GUIDE

Present NRC staff practice with regard to the calculation of radioactive emission rates from uranium milling facilities involves the characterization of such releases by radionuclide, particle size, and density (Ref. 1). The data required as input for use of the calculational models described in this guide consist of annual average air concentrations resulting directly from such releases at specific locations (not including resuspended air concentrations of radioactive materials previously deposited on ground surfaces). The required input air concentrations for a particular location are denoted in this guide by the symbol C_{adip} (in pCi/m^3), where the subscripts indicate air concentration (a), direct (d), radionuclide (i), and particle size (p). Direct air concentrations required are those for values of the subscripts i and p as identified and defined in Table 1.

The primary calculational tool employed by the staff in performing radiological impact evaluations of uranium milling operations is the MILDOS code (Ref. 2), a modified version of the Argonne National Laboratory Uranium Dispersion and Dosimetry (UDAD) Code (Ref. 4). As used by the NRC staff, the MILDOS code has only five primary radionuclides in the ^{238}U decay chain that are treated explicitly as source terms. These radionuclides are ^{238}U, ^{230}Th, ^{226}Ra, ^{210}Pb, and ^{222}Rn. Release rates for these radionuclides are required for each potential onsite source (for particle sizes 1 through 4 in Table 1). For ^{222}Rn daughters, which grow in during transport of ^{222}Rn from the site, the resulting ingrowth concentrations (particle size 5 in Table 1) are also required. These ^{222}Rn daughters include ^{218}Po, ^{214}Pb, ^{214}Bi, ^{210}Pb, and ^{210}Po. The dosimetry model accounts for releases and ingrowth of other radionuclides, using assumptions of secular equilibrium.

Appendix A identifies and describes the various other site-specific information and data routinely used by the NRC staff in performing radiological impact assessments for uranium milling facilities. Appendix B provides a more detailed discussion of the method used in this guide for calculating environmental dose commitments. Appendix C provides a detailed explanation of the derivation of the radon dose conversion factor used in this guide.

C. REGULATORY POSITION

Equations and other data by which the NRC staff will estimate radiation exposure for individuals and the population in general from uranium mills are presented below. These equations are appropriate for the exposure pathways that the staff routinely considers in its evaluations. In addition, other pathways that may be present because of unique conditions at a specific site should be considered if they are likely to provide a significant contribution to total dose. A pathway is considered significant if a conservative evaluation yields an additional dose increment of more than 10 percent of the total from all other pathways considered in this guide.

1. CONCENTRATIONS IN ENVIRONMENTAL MEDIA

As discussed in Section B.4, annual average direct air concentrations are required as input data for use in the equations that follow. These equations yield resulting concentrations in environmental media of interest, including total ground surface concentrations, air concentrations, and concentrations in edible vegetation, meat, and milk. These concentration calculations are explicitly performed only for certain radionuclides of the ^{238}U decay chain. Concentrations in environmental media of other radionuclides of the chain are inferred from those for which concentrations are explicitly calculated.

The basic calculational procedure first involves treatment of the direct air concentrations to obtain ground surface concentrations and resuspended air concentrations. Resuspension of radioactive materials deposited on ground surfaces is not treated as a loss mechanism for ground concentrations. For this reason, deposition of resuspended air concentrations onto ground surfaces is not considered. Resuspended particulate concentrations in air are added to the airborne concentrations arising directly from the source to obtain total air concentrations. The calculated total air concentrations are then used to obtain total deposition rates onto vegetation (resuspension losses of activity deposited on vegetation are assumed to be accounted for by the application of a weathering half-life). Total deposition rates and ground concentrations are used to compute concentrations in various vegetation types, including hay and forage. Radionuclide concentrations in hay and animal forage are initial inputs for the calculation of radionuclide concentrations in meat and milk ingested by man. This basic calculational process, the resulting environmental media concentrations, and the exposure pathways for which they are used are indicated schematically in Figure 1.

I.1 Radionuclide Accumulation on the Ground

Radionuclide ground concentrations are computed from the calculated airborne particulate concentrations arising directly from onsite sources (not including air concentrations resulting from resuspension). Resuspended particulate concentrations are not considered for evaluating ground concentrations. The direct deposition rate of radionuclide i is calculated, using the following relationship:

$$D_{di} = \sum_{p} C_{adip} V_p \qquad (1)$$

where

C_{adip} is the calculated direct air concentration of radionuclide i in particle size p in pCi/m^3;

D_{di} is the resulting direct deposition rate of radionuclide i in pCi/m^2 per sec; and

V_p is the deposition velocity of particle size p in m/sec (see Table 1).

The concentration of radionuclide i on a ground surface due to constant deposition at the rate D_{di} over time interval t is obtained from

$$C_{gi}(t) = D_{di}\left[\frac{1 - \exp[-(\lambda_i + \lambda_e)t]}{\lambda_i + \lambda_e}\right] \tag{2}$$

where

$C_{gi}(t)$ is the calculated ground surface concentration of radionuclide i at time t in pCi/m^2;

t is the time interval over which deposition has occurred in sec;

λ_e is the assumed rate constant for environmental loss in sec^{-1}; and

λ_i is the radioactive decay constant* for radionuclide i in sec^{-1}.

The environmental loss constant λ_e corresponds to an assumed half-time for loss of environmental availability of 50 years (Ref. 1). This parameter accounts for downward migration in soil and loss of availability due to chemical binding. It is assumed to apply to all radionuclides deposited on the ground.

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*Radiological decay constants employed by the NRC staff are obtained from data given in Reference 5.

Ground concentrations are explicitly computed only for ^{238}U, ^{230}Th, ^{226}Ra, and ^{210}Pb. For all other radionuclides, the ground concentration is assumed equal to that of the first parent radionuclide for which the ground concentration is explicitly calculated. For ^{210}Pb, ingrowth from deposited ^{226}Ra can be significant. The concentration of ^{210}Pb on the ground due to ^{226}Ra deposition is calculated by the staff, using the standard Bateman equation and ignoring the very-short-lived daughter radionuclides. This is equivalent to assuming that ^{226}Ra decays directly to ^{210}Pb. Using i = 6 for ^{226}Ra and i = 12 for ^{210}Pb (see Table 1), the following equation is obtained:

$$C_{g12}(Pb \leftarrow Ra) = \frac{\lambda_{12} D_{d6}}{\lambda_6^*} \left[\frac{1 - e^{-\lambda_{12}^* t}}{\lambda_{12}^*} + \frac{e^{-\lambda_6^* t} - e^{-\lambda_{12}^* t}}{\lambda_6^* - \lambda_{12}^*} \right] \qquad (3)$$

where

$C_{g12}(Pb \leftarrow Ra)$ is the incremental ^{210}Pb ground concentration resulting from ^{226}Ra deposition in pCi/m^2; and

λ_n^* is the effective rate constant for loss by radioactive decay and migration of a ground-deposited radionuclide and is equal to $\lambda_n + \lambda_e$ in sec^{-1}.

1.2 Total Air Concentrations

For use of the models described in this guide, air concentrations arising directly from onsite sources are required for each receptor location as a function of particle size (for particulates). Direct air concentrations are assumed to include the effects of depletion by deposition (particulates) or ingrowth and decay in transit (for radon and its daughters). In order to compute inhalation doses, the total air concentration of each radionuclide at each location (as a function of particle size) is computed as the sum of the direct air concentration and the resuspended air concentration:

$$C_{aip}(t) = C_{adip} + C_{arip}(t) \qquad (4)$$

where

C_{adip} is the calculated direct air concentration of radionuclide i in particle size p in pCi/m^3;

$C_{aip}(t)$	is the calculated total air concentration of radionuclide i in particle size p at time t in pCi/m^3; and
$C_{arip}(t)$	is the calculated resuspended air concentration of radionuclide i in particle size p at time t in pCi/m^3.

The resuspended air concentration is computed using a time-dependent and particle-size-dependent resuspension factor, which, for deposits of age t years, is defined by

$$R_p(t) = (0.01/V_p)10^{-5}\, e^{-\lambda_R t} \quad (\text{for } t \leq 1.82 \text{ yr}) \qquad (5a)$$

$$R_p(t) = (0.01/V_p)10^{-9} \quad (\text{for } t > 1.82 \text{ yr}) \qquad (5b)$$

where

$R_p(t)$	is the ratio of the resuspended air concentration to the ground concentration for a ground deposit of age t yr for particle size p in m^{-1};
λ_R	is the assumed decay constant of the resuspension factor (equivalent to a 50-day half-life), 5.06 yr^{-1};
0.01	is the deposition velocity for the particle size for which the initial resuspension factor value is 10^{-5}/m in m/sec;
10^{-5}	is the initial value of the resuspension factor for particles with a deposition velocity of 0.01 m/sec in m^{-1};
10^{-9}	is the terminal value of the resuspension factor for particles with a deposition velocity of 0.01 m/sec in m^{-1}; and
1.82	is the time required to reach the terminal resuspension factor in yr.

The basic formulation of the above expression for the resuspension factor, the initial and final values, and the assigned decay constant derive from experimental observations (Ref. 1). The decrease with age primarily accounts for agglomeration with other larger particles. The inverse relationship to deposition velocity physically accounts for decreased resuspendibility of larger particles; mathematically, it eliminates mass balance problems for the 35-μm particle size. Based on this formulation, the resuspended air concentration is given by

$$C_{arip}(t) = 0.01C_{adip}10^{-5}\left[\frac{1 - \exp[-(\lambda_i^* + \lambda_R)(t - a)]}{(\lambda_i^* + \lambda_R)} + 10^{-4}\ \delta(t)\ \frac{\exp[-\lambda_i^*(t - a)] - \exp(-\lambda_i^* t)}{\lambda_i^*}\right](3.156 \times 10^7) \quad (6)$$

where

a	is equal to $(t - 1.82)$ if $t > 1.82$ and is otherwise equal to zero in yr;
$\delta(t)$	is zero if $t \leq 1.82$ and is unity otherwise, dimensionless;
λ_i^*	is the effective removal constant for radionuclide i on soil in yr^{-1}; and
3.156×10^7	is the number of seconds per year.

Equation 6 yields the resuspended air concentration of radionuclide i in particle size p because of deposition over time span t in years. Total air concentrations are computed using Equations 6 and 4 (in that order) for all particulates in particle sizes 1 through 4 as given in Table 1. Particulate daughters of ^{222}Rn (particle size 5 in Table 1) are not assumed to be depleted because of deposition and are also not assumed to resuspend.

1.3 Vegetation Concentrations

As illustrated in Figure 1, vegetation concentrations are derived from ground concentrations and total deposition rates. Total deposition rates are given by the following summation:

$$D_i = \sum_p C_{aip}V_p \quad (7)$$

where

D_i	is the total deposition rate, including deposition of resuspended activity, of radionuclide i in pCi/m^2 per sec.

Concentrations of released particulate materials can be environmentally transferred to the edible portions of vegetables or to hay or pasture grass consumed by animals by two mechanisms--direct foliar retention and root uptake. Five categories of vegetation are treated by the staff. They are edible above-ground vegetables, potatoes, other edible below-ground vegetables, pasture grass, and hay. Vegetation concentrations are computed using the following equation:

$$C_{vi} = D_i F_r E_v \left[\frac{1 - \exp(-\lambda_w t_v)}{Y_v \lambda_w} \right] + C_{gi} \frac{B_{vi}}{p} \tag{8}$$

where

B_{vi}	is the soil-to-plant transfer coefficient for radionuclide i and vegetation type v (pCi/kg(wet) plant per pCi/kg(dry) soil);
C_{vi}	is the resulting concentration of radionuclide i in vegetation v in pCi/kg(wet weight);
E_v	is the fraction of the foliar deposition reaching edible portions of vegetation v, dimensionless;
F_r	is the fraction of the total deposition retained on plant surfaces, 0.2, dimensionless;
p	is the assumed soil areal density for surface mixing, 240 kg(dry weight)/m^2;
t_v	is the assumed duration of exposure while vegetation v is growing in sec;
Y_v	is the assumed yield density of vegetation v in kg(wet weight)/m^2; and
λ_w	is the decay constant accounting for weathering losses (equivalent to a 14-day half-life), 5.73×10^{-7} sec^{-1}.

The value of E_v is assumed to be 1.0 for all above-ground vegetation and 0.1 for all below-ground vegetables (Ref. 6). The value of t_v is taken to be 60 days, except for pasture grass for which a value of 30 days is assumed. The yield density Y_v is taken to be 2.0 kg/m^2, except for pasture grass for which a value of 0.75 kg/m^2 is applied. Values of the soil-to-plant transfer coefficients B_{vi} are provided in Table 2.

1.4 Meat and Milk Concentrations

Radioactive materials can be deposited on grasses, hay, or silage that are eaten by meat animals that are in turn eaten by man. The equation used to estimate radionuclide concentrations in meat is

$$C_{bi} = QF_{bi}(F_{pg}C_{pgi} + F_hC_{hi}) \qquad (9)$$

where

C_{bi} is the resulting average concentration of radionuclide i in meat in pCi/kg;

C_{hi} is the concentration of radionuclide i in hay (or other stored feed) in pCi/kg(wet weight);

C_{pgi} is the concentration of radionuclide i in pasture grass in pCi/kg(wet weight);

F_{bi} is the feed-to-meat transfer coefficient for radionuclide i in pCi/kg per pCi/day ingested (see Table 2);

F_{pg}, F_h are the fractions of the total annual feed requirement assumed to be satisfied by pasture grass or locally grown stored feed (hay), respectively, dimensionless; and

Q is the assumed feed ingestion rate, 50 kg(wet weight)/day (Ref. 6).

The equation used to estimate milk concentrations from cows ingesting contaminated feed is

$$C_{mi} = QF_{mi}(F_{pg}C_{pgi} + F_hC_{hi}) \qquad (10)$$

where

C_{mi} is the resulting average concentration of radionuclide i in milk in pCi/L; and

F_{mi} is the feed-to-milk transfer coefficient for radionuclide i in pCi/L per pCi/day ingested (see Table 2).

1.5 Concentrations at Different Times

Maximum doses to individuals are calculated for the last year of mill operation and for the last year prior to tailings pile reclamation. This section explains the procedures used by the NRC staff to obtain annual average environmental media concentrations for these years.

In order to estimate average environmental media concentrations during the final year of actual mill operation, for an operational lifetime of T_o years, the value of the time variable t appearing in Equations 2, 3, 4, and 6 is set equal to T_o (in appropriate units). The resulting concentration values are those predicted for the end of the final year of operation and are assumed to represent average values existing over that year.

Environmental concentrations existing during the final prereclamation year result from postoperational releases and residual contamination due to releases during the period of mill operation. Because direct air concentrations from operational releases vanish, environmental concentrations due to operational releases at the time of reclamation arise only from residual ground and resuspended air concentrations. Ground concentrations at the end of the milling period are calculated using Equations 2 and 3, with the value of t set to T_o, the operational lifetime. Residual ground concentrations at the end of the final prereclamation year are then determined by

$$C_{gi}(T_d) = C_{gi}(T_o)\exp[-\overset{*}{\lambda}_i(T_d)] \qquad (11)$$

where

$C_{gi}(T_d)$	is the residual ground concentration of radionuclide i resulting from operational releases at the end of the T_d-year drying period in pCi/m^2;
$C_{gi}(T_o)$	is the ground concentration of radionuclide i at the time of mill shutdown in pCi/m^2; and
T_d	is the duration of time required to dry the tailings pile prior to reclamation per yr.

Residual resuspended air concentrations resulting from operational releases are determined at the end of the final prereclamation year by

$$C_{arip}(T_d) = 0.01C_{adip}10^{-9}\ \exp[-\lambda_i^{\star}(T_d)] \times \left[\frac{1 - \exp(-\lambda_i^{\star}T_o)}{\lambda_i^{\star}}\right](3.156 \times 10^7) \qquad (12)$$

where

C_{adip} is the direct air concentration of radionuclide i in particle size p resulting from operational releases in pCi/m^3; and

$C_{arip}(T_d)$ is the residual resuspended air concentration of radionuclide i in particle size p resulting from operational releases at the end of the T_d-year drying period in pCi/m^3.

Ground and resuspended air concentrations resulting from postoperational releases at the end of the final prereclamation year are calculated using Equations 2, 3, 4, and 6 with the value of t equal to T_d. These concentrations are then incremented by the residual concentrations due to operational releases. These residual concentrations are calculated using Equations 11 and 12 to obtain the required totals. Total air concentrations and concentrations in vegetation, meat, and milk are then calculated from the total ground and resuspended air concentrations.

2. DOSE CALCULATIONS FOR INDIVIDUALS

Doses to individuals are calculated for inhalation, external exposure to air and ground concentrations, and ingestion of vegetables, milk, and meat. Internal doses are calculated using dose conversion factors that yield the 50-year committed dose equivalent, i.e., the entire dose received over a period of 50 years following either inhalation or ingestion. The annual doses are actually the 50-year committed dose equivalents resulting from a 1-year exposure period. The 1-year exposure period is taken to be the year when environmental concentrations resulting from plant operations are expected to be at their highest level.

2.1 Inhalation Doses

Inhalation doses are calculated from the total radionuclide concentration in air, including resuspended material. The inhalation dose conversion factors for radioactive particulate materials used in this analysis are presented in Table 3. With the exception of the dose conversion factors presented for "mass average lung," these dose conversion factors have been computed by Argonne National Laboratory's UDAD computer code (Ref. 4) in accordance with the Task Group Lung Model (TGLM) of the International Commission on Radiological Protection (Ref. 7). Dose conversion factors for the mass average lung have been computed by mass-averaging the UDAD-calculated dose conversion factors for the four regions of the TGLM: nasopharyngeal, tracheobronchial, pulmonary, and lymph. Ordinarily, the dose computed specifically for the pulmonary region is reported or presented as the "lung" dose. For the principal lung dose contributors (uranium and thorium), doses computed for the mass average lung are slightly higher than those calculated for the pulmonary region. The net overall effect, considering all radionuclides, is thus a slight increase in the reported lung dose.

In addition to the physical characteristics of the particulate matter involved, use of the TGLM demands the assignment of a solubility class, denoted by Y (years, slowly soluble or insoluble), W (weeks, moderately soluble), or D (days, quite soluble). Solubility classifications have been assigned on the basis of experimental data reported and summarized by Kalkwarf in NUREG/CR-0530 (Ref. 8). These data indicate that thorium, lead, and polonium are 100% class Y in ore, yellowcake, or tailings dusts. Radium was determined to be best characterized by the split-solubility classification 10% class D, 90% class Y. Uranium in ore dust was determined to be 100% class W; uranium solubility for tailings dusts was not analyzed and is assumed to be class Y. Data for uranium in yellowcake were mixed and showed a pronounced dependence on the specific source of the yellowcake sample. Results reported by Kalkwarf indicate a split-solubility classification is appropriate, and on review of those results (particularly those given on page 55 of Reference 8), the staff has assumed uranium in yellowcake to be 50% class D and 50% class Y. The computed inhalation dose conversion factors are given in Table 3.

Doses to the bronchial epithelium from ^{222}Rn and short-lived daughters are computed based on the assumption of indoor exposure with 100% occupancy.

The dose conversion factor for bronchial epithelium exposure from ^{222}Rn is derived as follows (see Appendix C for detailed basis):

1. 1 pCi/m^3 ^{222}Rn in outdoor air will yield an average indoor concentration of about 5×10^{-6} Working Level (WL).*
2. Continuous exposure to 1 WL = 25 cumulative working-level months (WLM) per year.
3. 1 WLM = 5000 mrem (Ref. 9).

Therefore,

$$1 \text{ pCi/m}^3 \; ^{222}\text{Rn} \times (5 \times 10^{-6} \frac{\text{WL}}{\text{pCi/m}^3}) \times (25 \frac{\text{WLM}}{\text{WL}})$$

$$\times (5000 \frac{\text{mrem}}{\text{WLM}}) = 0.625 \text{ mrem}$$

and the ^{222}Rn bronchial epithelium dose conversion factor is taken to be 0.625 mrem/yr per pCi/m^3.

Inhalation doses are computed by the staff by use of the following equation:

$$d_j(\text{inh}) = \sum_{ip} C_{aip} DCF_{ijp}(\text{inh}) \qquad (13)$$

where

$d_j(\text{inh})$ is the inhalation dose to organ j in mrem/yr; and

$DCF_{ijp}(\text{inh})$ is the inhalation dose conversion factor for radionuclide i, organ j, and particle size p in mrem/yr per pCi/m^3.

2.2 External Doses

External doses resulting from exposure to air and ground activity concentrations are computed, using the dose conversion factors presented in Table 4 and assuming 100 percent occupancy at a given location. Indoor exposure is assumed to occur 14 hours per day at a dose rate of 70 percent of the outdoor dose rate, which is equivalent to a dose reduction factor for structural shielding of 0.825. The following equation is used by the staff to calculate external doses:

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*One WL concentration is defined as any combination of short-lived radioactive decay products of ^{222}Rn per liter of air that will release 1.3×10^5 MeV of alpha-particle energy during their radioactive decay to ^{210}Pb.

$$d_j(\text{ext}) = 0.825 \sum_i C_{ai} DCF_{ij}(\text{cld}) + C_{gi} DCF_{ij}(\text{gnd}) \qquad (14)$$

where

C_{ai}	is the total air concentration of radionuclide i in pCi/m^3;
$d_j(\text{ext})$	is the external dose to organ j in mrem/yr;
$DCF_{ij}(\text{cld})$	is the dose conversion factor for cloud exposure from radionuclide i to organ j in mrem/yr per pCi/m^3;
$DCF_{ij}(\text{gnd})$	is the dose conversion factor for ground exposure from radionuclide i to organ j in mrem/yr per pCi/m^2; and
0.825	is the effective reduction factor because of structural shielding for indoor exposure periods.

2.3 Ingestion Doses

Ingestion doses are routinely calculated for ingestion of vegetables and meat (beef, unprocessed pork, and lamb). Milk ingestion doses are also computed if that pathway exists at the time of licensing. Ingestion doses are based on environmental concentrations established using Equations 8, 9, and 10, ingestion rates given in Table 5, and dose conversion factors given in Table 6. Ingestion doses from vegetable consumption are computed under the assumption that an average of 50 percent of the initial activity will be lost in food preparation (Ref. 6), usually involving washing, peeling, boiling, etc. The following equation is used to compute the annual radionuclide intake via ingestion:

$$I_{ik} = U_{mk} C_{mi} + U_{bk} C_{bi} + 0.5 \sum_v U_{vk} C_{vi} \qquad (15)$$

where

I_{ik}	is the activity ingestion rate of radionuclide i by an individual in age group k in pCi/yr;

U_{mk}, U_{bk}	are milk (in L/yr) and meat (in kg/yr) ingestion rates for an individual in age group k;
U_{vk}	is the ingestion rate of vegetable category v for age group k in kg(wet weight)/yr; and
0.5	is the fraction of vegetable activity remaining after food preparation, dimensionless.

Ingestion doses are then computed by

$$d_{jk}(ing) = \sum_{i} I_{ik} DCF_{ijk}(ing) \qquad (16)$$

where

$d_{jk}(ing)$	is the ingestion dose for organ j of an individual in age group k in mrem/yr; and
$DCF_{ijk}(ing)$	is the ingestion dose conversion factor for radionuclide i in organ j of an individual in age group k in units of mrem/pCi ingested.

2.4 Individual Dose Totals

Individual doses are calculated by the NRC staff for purposes of evaluating compliance with 10 CFR Part 20 and 40 CFR Part 190. For evaluating compliance with 40 CFR Part 190, dose contributions from ^{222}Rn and daughters are excluded. Total doses to individuals are calculated for both purposes using the following equation, which sums the dose contributions from inhalation, external dose, and ingestion:

$$d_{jk}(tot) = d_j(inh) + d_j(ext) + d_{jk}(ing) \qquad (17)$$

where

$d_{jk}(tot)$	is the total dose to organ j of an individual in age group k from all exposure pathways in mrem/yr.

To evaluate compliance with 40 CFR Part 190, the staff will compute total doses to appropriate individual receptors, using the above equation and all other models, data, and assumptions described in this guide, except that--

1. all dose contributions from radiation emitted by ^{222}Rn, ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po will be excluded, and
2. all dose contributions from radiation emitted by ^{210}Pb, ^{210}Bi, and ^{210}Po formed by decay of released ^{222}Rn will be excluded.

With reference to Table 1 of this guide, the dose contributions eliminated for the purpose of evaluating compliance with 40 CFR Part 190 include those due to any radiation emitted by (a) radionuclides for which $i = 7, 8, 9, 10$, or 11 and (b) radionuclides present in particle size category $p = 5$ (radon daughters). The staff will add to dose totals computed for evaluating compliance with 40 CFR Part 190 any known significant doses resulting from any other light-water-cooled nuclear power generating or fuel cycle facilities, as appropriate (excluding doses from ^{222}Rn and its daughters as stipulated above and excluding doses from any radioactive materials released by nuclear or other facilities or operations not included under 40 CFR Part 190).

3. POPULATION DOSE CALCULATIONS

Population doses are calculated, using the environmental dose commitment concept with an integrating period of 100 years (Ref. 3). Under this approach, radiological impacts for a given release of activity are integrated over a time interval of 100 years following the release. The 100-year environmental dose commitment resulting from average release rates over a 1-year period is computed for (1) the period of actual uranium milling and (2) the period of time after the cessation of milling during which tailings are allowed to dry prior to final stabilization and reclamation. The NRC staff's rationale for the selection and use of a 100-year integrating period and the staff's technique for computing environmental dose commitments are addressed in Appendix B to this guide.

Population doses resulting from particulate and radon releases are evaluated over the general region of the facility site for the first two phases of the mill life cycle: operational (milling) and prereclamation. For these two time intervals and for the postreclamation era, annual population dose commitments resulting from transcontinental dispersion of ^{222}Rn are also evaluated.

3.1 Regional Population Doses

Population doses resulting from environmental radioactivity concentrations in the region of the site are evaluated for all exposure pathways considered in the evaluation of maximum individual doses; other pathways should also be considered if they are likely to result in an increase of more than 10 percent to the total result. Regional population dose commitments are generally computed on the basis of the population and agricultural productivity within a distance of 80 km (50 mi). Individual localized population centers lying beyond this distance should also be considered if their inclusion would increase the population dose estimates by more than 10 percent.

3.1.1 Inhalation and External Doses

Inhalation and external doses are computed by the NRC staff, using the identical models, equations, data, and assumptions as previously described for individual dose calculations in Regulatory Positions 1 and 2 of this guide. The procedure for calculating regional population doses from those pathways is to (1) divide the geographical site region into segments by radius and direction, (2) establish average individual doses within each segment, (3) multiply these individual doses by the estimated population lying within each segment, and (4) sum over all segments.

The population distribution required is that projected for the final year of mill operation. The appropriate population projection should be presented for each segment formed by radii extending outward from the site and bisecting the 16 compass directions (forming 22.5° sectors) and concentric circles drawn at distances of 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km. The 13 circles and 16 radii then form a grid composed of 192 individual segments. Average doses over the population within each segment are computed by the NRC staff along the segment directional centerline at a distance midway between the inner and outer boundaries of each annulus.

The population dose in the site region from inhalation and external exposure pathways is computed by the staff using the following equation:

$$M_j(\text{inh} + \text{ext}) = 10^{-3} \sum_s P_s[d_{js}(\text{inh}) + d_{js}(\text{ext})] \qquad (18)$$

where

$d_{js}(ext)$	is the average external dose to organ j in segment s in mrem/yr;
$d_{js}(inh)$	is the average inhalation dose to organ j in segment s in mrem/yr;
$M_j(inh+ext)$	is the resulting population dose from inhalation and external exposure pathways in rem/yr;
P_s	is the population residing in segment s; and
10^{-3}	is the conversion factor from millirem to rem.

3.1.2 Food Ingestion Doses

Collective population doses from food ingestion are calculated on the basis of the region's agricultural productivity rather than its population. This is because the total population dose from food pathways is proportional to the total quantity of radionuclides in all food produced in the region rather than the number of people exposed. The model employed by the NRC staff considers population doses resulting from radioactive contamination of vegetable, meat, and milk products produced in the region. For population dose calculations, the vegetable category includes fruit and grain crops as well. The procedure followed by the staff to compute food ingestion doses is similar to that used for inhalation and external doses and is composed of the following procedural steps:

1. The site region is divided into segments and each segment is assigned a productivity rate for each food category (vegetables, meat, and milk in kg/yr per km^2);
2. The average activity concentrations for each food type are computed and multiplied by the segment productivity factor and by the segment area;
3. Total activity content of the regional food production is then determined by summing over the segments; and
4. Population doses are determined assuming that all food produced in the region is consumed by a population with the same age distribution as the U.S. population.

Agricultural productivity data required for use in this analysis are generally available on a county-by-county basis for a relatively recent year.

The available raw data should be projected forward in time to provide a reasonable estimate of productivity during the final year of mill operation. If other means are not available, the NRC staff considers it acceptable to assume that regional agricultural productivity will remain in constant proportion to the U.S. population. Should other site-specific data not be available, the staff will rely on the statewide average productivity data presented in Table 7. The following equation is used to obtain segment average radionuclide concentrations in vegetables:

$$C_{vis}(avg) = \sum_{v} W_{vs} C_{vis} \qquad (19)$$

where

C_{vis}	is the average concentration of radionuclide i in vegetable type v produced in segment s in pCi/kg(wet weight);
$C_{vis}(avg)$	is the average concentration of radionuclide i averaged over all types of vegetables in segment s in pCi/kg; and
W_{vs}	is the weighting factor for vegetable type v in segment s (fraction of total production), dimensionless.

When relying on the state-average production data given in Table 7, the NRC staff will use values of W_v that have been selected to roughly correspond to the fractions of the three vegetable types in the average diet. From Reference 1, these W_v values are 0.78 for above-ground vegetables, 0.20 for potatoes, and 0.02 for other below-ground vegetables.

The gross activity content of the regional food production for each food type (vegetables, meat, or milk) is obtained by

$$Q_{fi} = \sum_{s} G_{fs} A_s C_{fis} \qquad (20)$$

where

A_s	is the area of segment s in km^2;
C_{fis}	is the concentration of radionuclide i in food category f in segment s in pCi/kg(wet weight);
G_{fs}	is the productivity factor for food f in segment s in kg/yr per km^2; and

Q_{fi} is the gross activity content of radionuclide i in food f in pCi/yr.

Since the food produced may be eaten at different rates by different age groups and since ingestion dose conversion factors are also age dependent, it is necessary to establish the fractions of the Q_{fi} values determined by Equation 20 that are ingested by the various age groups. The following relationship applies:

$$F_{fk} = \frac{F_{pk}U_{fk}}{\sum\limits_{k} F_{pk}U_{fk}} \qquad (21)$$

where

F_{fk} is the fraction of the production of food type f ingested by individuals in age group k, dimensionless;

F_{pk} is the fraction of the regional population belonging to age group k, dimensionless; and

U_{fk} is the average consumption rate in kg/yr or L/yr (for milk or other liquids) of food type f for an individual in age group k (see Table 8 for values). In the absence of suitable site-specific information, the NRC staff will assume average consumption rates for the population at large as given in Table 8 and population age fractions and fractional consumption rates as given in Table 9.

Using values obtained from Equations 20 and 21, total population ingestion doses from all food categories are calculated by

$$M_j(\text{ing}) = 10^{-3} \sum_{fik} E_f Q_{fi} F_{fk} DCF_{ijk}(\text{ing}) \qquad (22)$$

where

E_f is a factor to account for activity remaining after food preparation, dimensionless; and

$M_j(\text{ing})$ is the resulting regional population dose from food ingestion for organ j in rem/yr.

The value of E_f is assumed to be 0.5 for vegetables and 1.0 for meat and milk. Fractions of the population belonging to the various age groups used in Equation 20 are determined from U.S. census data in the absence of site-specific information (see Table 9 for values).

3.2 Continental Population Doses

Substantial contributions to the total population dose may arise from the transport of released ^{222}Rn across the North American continent. Formation of long-lived ^{210}Pb from ^{222}Rn may result in both inhalation and ingestion doses not only to people in the United States, but to people in Canada and Mexico as well (Ref. 10). In order to estimate population doses occurring beyond the immediate region of the site, the staff makes use of the data presented in Table 10. These data consist of estimates of population doses resulting from 1,000-Ci releases of ^{222}Rn from four specific locations in the western United States. The location closest to the mill site should be used. The population doses provided are those that would have resulted from releases during calendar year 1978, including doses to Canadian and Mexican populations, and are based on the use of the environmental dose commitment concept with an integrating period of 100 years.

For projected releases of ^{222}Rn in future years, resulting population doses are computed by assuming those doses to be proportional to the U.S. population (use the population data provided in Table 11). The anticipated annual ^{222}Rn release in kCi is multiplied by the appropriate population doses from Table 10, and these results are then multiplied by the ratio of the projected U.S. population for the year of release to the 1978 U.S. population.

3.3 Total Population Dose Commitments

Population doses over the site region and the North American continent are computed on an annual basis for the operational (milling), prereclamation (pile drying), and postreclamation phases. The total radiological impact due to emissions during the first two phases is estimated by multiplying the annual impacts by the durations and summing. Total annual impacts for each of the three phases are obtained by

$$M_j = M_j(\text{inh} + \text{ext}) + M_j(\text{ing}) + M_j(\text{Rn}) \qquad (23)$$

where

M_j	is the annual committed population dose to organ j in rem/yr; and
$M_j(\text{Rn})$	is the annual continental population dose from ^{222}Rn and its daughters to organ j in rem/yr.

Total impacts over the first two phases are obtained by

$$M_j(\text{m\&d}) = T_o M_j(\text{m}) + T_d M_j(\text{d}) \qquad (24)$$

where

$M_j(\text{d})$	is the annual committed population dose to organ j during the drying phase in rem/yr;
$M_j(\text{m})$	is the annual committed population dose to organ j during the milling phase in rem/yr;
$M_j(\text{m\&d})$	is the aggregate committed population dose to organ j over the milling and drying phases in rem; and
T_o, T_d	are the durations of the operational and pile-drying phases, respectively, in yr.

The calculation, compilation, and presentation of these population doses is considered by the NRC staff to represent a reasonably complete description of the radiological impact incurred by the operation of a typical uranium mill.

D. IMPLEMENTATION

The models specified in this guide are being used by the NRC staff in evaluating radiological impact in connection with applications for uranium mill licenses and renewals.

Table 1

ISOTOPES AND PARTICLE SIZES FOR WHICH DIRECT AIR CONCENTRATIONS (C_{adip} VALUES) ARE REQUIRED AS INPUT DATA

	Particle Size Group Characteristics (Ref. 1)				
Particle Size Group*	Diameter Range, μm	Mean Diameter, μm	Density, g/cm³	Unit Density Activity--Median Aerodynamic Equivalent Diameter (AMAD), μm	Deposition Velocity, m/sec
p = 1	-	1.0	8.9	3.0	1.0×10^{-2}
p = 2	-	1.0	2.4	1.5	1.0×10^{-2}
p = 3	1 to 10	5.0	2.4	7.75	1.0×10^{-2}
p = 4	10 to 80	35.0	2.4	54.0	8.82×10^{-2}
p = 5	-	0.3	1.0	0.3	0.3×10^{-2}

		Particle Size Group Index**				
i	Radionuclide	p = 1	p = 2	p = 3	p = 4	p = 5
1	uranium-238	C & R	C & R	C & R	C & R	-
2	thorium-234	se	se	se	se	-
3	protactinium-234	se	se	se	se	-
4	uranium-234	se	se	se	se	-
5	thorium-230	C & R	C & R	C & R	C & R	-
6	radium-226	C & R	C & R	C & R	C & R	-
7	radon-222***	se	se	se	se	-
8	polonium-218	se	se	se	se	C & R
9	lead-214	se	se	se	se	C & R
10	bismuth-214	se	se	se	se	C & R
11	polonium-214	se	se	se	se	se
12	lead-210	C & R	C & R	C & R	C & R	C & R
13	bismuth-210	se	se	se	se	C & R
14	polonium-210	se	se	se	se	C & R

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*Particle size groups are assigned to effluents as follows: p = 1 for yellowcake dust; p = 2, 3, or 4 for fugitive ore and tailings dusts; p = 5 for ^{222}Rn air ingrowth concentrations of particulate daughters.

**The entry "C & R" indicates that the particular C_{adip} value is explicitly calculated by the staff and required as input for use of the models, equations, and data described in this guide. The entry "se" indicates that radionuclide is assumed to be in secular equilibrium with the next-higher-up parent for which the direct air concentration is explicitly calculated.

***The air concentration of ^{222}Rn is also calculated by the staff and is required as input for use of this guide; ^{222}Rn gas is not assigned a particle size.

Table 2

ENVIRONMENTAL TRANSFER COEFFICIENTS*

	Transfer Coefficent			
	U	Th	Ra	Pb
Plant/Soil (B_{vi})				
(pCi/kg plant - wet weight)/(pCi/kg soil - dry weight)				
Edible Above Ground	2.5×10^{-3}	4.2×10^{-3}	1.4×10^{-2}	4.0×10^{-3}
Potatoes	2.5×10^{-3}	4.2×10^{-3}	3.0×10^{-3}	4.0×10^{-3}
Other Below Ground	2.5×10^{-3}	4.2×10^{-3}	1.4×10^{-2}	4.0×10^{-3}
Pasture Grass	2.5×10^{-3}	4.2×10^{-3}	1.8×10^{-2}	2.8×10^{-2}
Stored Feed (Hay)	2.5×10^{-3}	4.2×10^{-3}	8.2×10^{-2}	3.6×10^{-2}
Beef/Feed (F_{bi})				
(pCi/kg per pCi/day)	3.4×10^{-4}	2.0×10^{-4}	5.1×10^{-4}	7.1×10^{-4}
Milk/Feed (F_{mi})				
(pCi/L per pCi/day)	6.1×10^{-4}	5.0×10^{-6}	5.9×10^{-4}	1.2×10^{-4}

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* Sources for these data include References 11-14.

Table 3

INHALATION DOSE CONVERSION FACTORS

Conversion Factor, mrem/yr per pCi/m^3

Radon Decay Products

Particle Size = 0.3 micron Density = 1.0 g/cm^3 AMAD = 1.0 microns	^{210}Pb	^{210}Po
Whole Body	7.46E+00	1.29E+00
Bone	2.32E+02*	5.24E+00
Kidney	1.93E+02	3.87E+01
Liver	5.91E+01	1.15E+01
Mass Average Lung	6.27E+01	2.66E+02

Yellowcake Dust

Particle Size = 1.0 micron Density = 8.9 g/cm^3 AMAD = 3 microns	^{238}U	^{234}U	^{230}Th	^{226}Ra	^{210}Pb	^{210}Po
Whole Body	9.82E+00	1.12E+01	1.37E+02	3.58E+01	4.66E+00	5.95E-01
Bone	1.66E+02	1.81E+02	4.90E+03	3.58E+02	1.45E+02	2.43E+00
Kidney	3.78E+01	4.30E+01	1.37E+03	1.26E+00	1.21E+02	1.79E+01
Liver	0.0	0.0	2.82E+02	4.47E-02	3.69E+01	5.34E+00
Mass Average Lung	1.07E+3	1.21E+3	2.37E+03	4.88E+03	5.69E+02	3.13E+02

Uranium Ore Dust

Particle Size = 1.0 micron Density = 2.4 g/cm^3 AMAD = 1.5 microns	^{238}U	^{234}U	^{230}Th	^{226}Ra	^{210}Pb	^{210}Po
Whole Body	4.32E+00	4.92E+00	1.66E+02	3.09E+01	4.36E+00	4.71E-01
Bone	7.92E+01	7.95E+01	5.95E+03	3.09E+02	1.35E+02	1.92E+00
Kidney	1.66E+01	1.89E+01	1.67E+03	1.09E+00	1.13E+02	1.42E+01
Liver	0.0	0.0	3.43E+02	3.87E-02	3.45E+01	4.22E+00
Mass Average Lung	1.58E+02	1.80E+02	3.22E+03	6.61E+03	7.72E+02	4.20E+02

Fine Tailings Particulates

Particle Size = 5.0 microns Density = 2.4 g/cm^3 AMAD = 7.75 microns	^{238}U	^{234}U	^{230}Th	^{226}Ra	^{210}Pb	^{210}Po
Whole Body	1.16E+00	1.32E+00	1.01E+02	4.00E+01	4.84E+00	7.10E-01
Bone	1.96E+01	2.14E+01	3.60E+03	4.00E+02	1.50E+02	2.89E+00
Kidney	4.47E+00	5.10E+00	1.00E+03	1.41E+00	1.25E+02	2.13E+01
Liver	0.0	0.0	2.07E+02	4.97E-02	3.83E+01	6.36E+00
Mass Average Lung	1.24E+03	1.42E+03	1.38E+03	2.84E+03	3.30E+02	1.88E+02

Coarse Tailings Particulates

Particle Size = 35.0 microns Density = 2.4 g/cm^3 AMAD = 54 microns	^{238}U	^{234}U	^{230}Th	^{226}Ra	^{210}Pb	^{210}Po
Whole Body	7.92E-01	9.02E-01	5.77E+01	4.90E+01	4.43E+00	7.28E-01
Bone	1.34E+01	1.46E+01	2.07E+03	3.90E+02	1.38E+02	2.96E+00
Kidney	3.05E+00	3.47E+00	5.73E+02	1.38E+00	1.15E+02	2.19E+01
Liver	0.0	0.0	1.19E+02	4.85E-02	3.51E+01	6.52E+00
Mass Average Lung	3.33E+02	3.80E+02	3.71E+02	7.64E+02	8.70E+01	5.75E+01

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*Read 2.32E+02 as $2.32 \times 10^2 = 232$.

Table 4

DOSE CONVERSION FACTORS FOR EXTERNAL EXPOSURE

	Dose Factor for External Dose from Air Concentrations mrem/yr per pCi/m^3	
Radionuclide	Skin	Whole Body*
^{238}U	1.05E-05**	1.57E-06
^{234}Th	6.63E-05	5.24E-05
^{234m}Pa	8.57E-05	6.64E-05
^{234}U	1.36E-05	2.49E-06
^{230}Th	1.29E-09	3.59E-06
^{226}Ra	6.00E-05	4.90E-05
^{222}Rn	3.46E-10	2.83E-06
^{218}Po	8.18E-07	6.34E-07
^{214}Pb	2.06E-03	1.67E-03
^{214}Bi	1.36E-02	1.16E-02
^{214}Po	9.89E-07	7.66E-07
^{210}Pb	4.17E-05	1.43E-05

	Dose Factor for External Dose from Ground Concentrations mrem/yr per pCi/m^2	
Radionuclide	Skin	Whole Body*
^{238}U	2.13E-06	3.17E-07
^{234}Th	2.10E-06	1.66E-06
^{234m}Pa	1.60E-06	1.24E-06
^{234}U	2.60E-06	4.78E-07
^{230}Th	2.20E-06	6.12E-07
^{226}Ra	1.16E-06	9.47E-07
^{222}Rn	6.15E-08	5.03E-08
^{218}Po	1.42E-08	1.10E-08
^{214}Pb	3.89E-05	3.16E-05
^{214}Bi	2.18E-04	1.85E-04
^{214}Po	1.72E-08	1.33E-08
^{210}Pb	6.65E-06	2.27E-06

---

*Doses to internal body organs are assumed to be the same as computed for the whole body.

**Read as 1.05 x 10^{-5} or 0.0000105.

Table 5

FOOD CONSUMPTION RATES USED FOR CALCULATING DOSES TO INDIVIDUALS

	Ingestion Rate by Age Group,* kg/yr			
	Infant	Child	Teen	Adult
Vegetables (Total)	-	47.8	76.1	105.
Edible Above Ground	-	17.3	28.9	39.9
Potatoes	-	27.2	42.2	60.4
Other Below Ground	-	3.3	5.0	5.0
Meat (Beef, Fresh Pork, and Lamb)	-	27.6	44.8	78.3
Milk (L/yr)	208.0	208.0	246.0	130.0

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*All data are taken from Reference 6. Ingestion rates are averages for typical farm households. No allowance is routinely credited for portions of year when locally grown or home-grown food may not be available.

Table 6

INGESTION DOSE CONVERSION FACTORS

	Internal Dose Conversion Factor by Organ and Age, mrem per pCi ingested								
Age Group	Organ	^{238}U	^{234}U	^{234}Th	^{230}Th	^{226}Ra*	^{210}Pb	^{210}Bi	^{210}Po
Infant	Wh. Bod	3.33E-04	3.80E-04	2.00E-08	1.06E-04	1.07E-02	2.38E-03	3.58E-07	7.41E-04
	Bone	4.47E-03	4.88E-03	6.92E-07	3.80E-03	9.44E-02	5.28E-02	4.16E-06	3.10E-03
	Liver	0	0	3.77E-08	1.90E-04	4.76E-05	1.42E-02	2.68E-05	5.93E-03
	Kidney	9.28E-04	1.06E-03	1.39E-07	9.12E-04	8.71E-04	4.33E-02	2.08E-04	1.26E-02
Child	Wh. Bod	1.94E-04	2.21E-04	9.88E-09	9.91E-05	9.87E-03	2.09E-03	1.69E-07	3.67E-04
	Bone	3.27E-03	3.57E-03	3.42E-07	3.55E-03	8.76E-02	4.75E-02	1.97E-06	1.52E-03
	Liver	0	0	1.51E-08	1.78E-04	1.84E-05	1.22E-02	1.02E-05	2.43E-03
	Kidney	5.24E-04	5.98E-04	8.02E-08	8.67E-04	4.88E-04	3.67E-02	1.15E-04	7.56E-03
Teenager	Wh. Bod	6.49E-05	7.39E-05	3.31E-09	6.00E-05	5.00E-03	7.01E-04	5.66E-08	1.23E-04
	Bone	1.09E-03	1.19E-03	1.14E-07	2.16E-03	4.09E-02	1.81E-02	6.59E-07	5.09E-04
	Liver	0	0	6.68E-09	1.23E-04	8.13E-06	5.44E-03	4.51E-06	1.07E-03
	Kidney	2.50E-04	2.85E-04	3.81E-08	5.99E-04	2.32E-04	1.72E-02	5.48E-05	3.60E-03
Adult	Wh. Bod	4.54E-05	5.17E-05	2.13E-09	5.70E-05	4.60E-03	5.44E-04	3.96E-08	8.59E-05
	Bone	7.67E-04	8.36E-04	8.01E-08	2.06E-03	4.60E-02	1.53E-02	4.61E-07	3.56E-04
	Liver	0	0	4.71E-09	1.17E-04	5.74E-06	4.37E-03	3.18E-06	7.56E-04
	Kidney	1.75E-04	1.99E-04	2.67E-08	5.65E-04	1.63E-04	1.23E-02	3.83E-05	2.52E-03

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*Adult whole body and bone dose conversion factors for ^{226}Ra have been obtained from Reference 6 and are based on applicable models and data from Reference 15. ^{226}Ra whole body and bone dose conversion factors for other age groups have been computed by assuming the same proportion to adult whole body and bone dose factors as given in Reference 16. All other dose conversion factors are directly from Reference 16.

Table 7

AVERAGE AGRICULTURAL PRODUCTIVITY FACTORS FOR VARIOUS STATES

	State-Average Productivity,* kg/yr per km^2		
State	Vegetables	Meat	Milk
Arizona	580	1,040	1,130
Colorado	2,800	3,200	1,400
Idaho	14,200	2,000	3,400
Montana	1,800	2,000	370
Nevada	18	510	230
New Mexico	280	1,150	460
South Dakota	2,400	6,400	3,600
Texas	1,200	5,300	2,100
Utah	370	790	1,800
Washington	10,700	1,600	6,000
Wyoming	320	1,400	230

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*Data presented are based on a staff survey and analysis of available data on agricultural productivity for 1973.

Table 8

FOOD CONSUMPTION RATES USED FOR CALCULATING DOSES TO POPULATIONS

Food Category	Average Consumption Rates,* kg/yr)			
	Infants	Children	Teens	Adults
Vegetable Pathway				
Berries and Tree Fruit	0	54.1	63.9	49.2
Fresh Vegetables**				
1. Potatoes	0	27.2	42.3	60.4
2. Other root veg.	0	3.4	5.0	5.0
3. Leafy vegetables	0	5.8	9.4	13.9
4. Other above-ground vegetables	0	11.4	19.5	26.0
Processed Vegetables				
1. Potatoes	0	2.3	3.6	5.2
2. Other root veg.	0	0.9	1.4	1.4
3. Leafy vegetables	0	0.4	0.6	0.8
4. Other above-ground vegetables	0	14.4	24.6	32.8
Grain, Rice, and Wheat	0	118.2	136.2	90.8
Total Vegetables	0	238.1	306.5	285.5
Meat Pathway				
Beef and Lamb**	0	21.8	35.9	64.0
Unprocessed Pork**	0	5.9	8.9	14.3
Poultry and Processed Pork	0	21.0	33.2	49.6
Total Meat	0	48.7	78.0	127.9
Milk Pathway (L/yr)				
Fresh Milk**	207.6	207.6	246.0	129.6
Milk Products	0	27.2	45.4	46.7
Total Milk	207.6	234.8	291.4	176.3

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[*] All data are taken from Reference 6 and are representative of average consumption rates by individuals at farm residences.

[**] These food categories are evaluated for individual doses from ingestion pathways.

Table 9

AGE DISTRIBUTION OF POPULATION, AVERAGE AND PER CAPITA CONSUMPTION RATES, AND FRACTIONS USED IN THE ABSENCE OF SITE-SPECIFIC DATA

Age Group	Fraction of Population*	Average Total Consumption Rates,** kg/yr		
		Vegetables	Meat	Milk
Infants	0.0179	0	0	207.6
Children	0.1647	238.1	48.7	234.8
Teenagers	0.1957	306.5	78.0	291.4
Adults	0.6217	285.5	127.9	176.3

Age Group	Fraction of Regional Production Ingested by Each Age Group		
	Vegetables	Meat	Milk
Infants	0	0	0.0178
Children	0.1418	0.0780	0.1850
Teenagers	0.2167	0.1485	0.2728
Adults	0.6415	0.7735	0.5244

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* Age fractions given reflect average values for the entire U.S. population indicated by 1970 census data, as reported in Reference 17.

** Consumption rates given are from Table 8 and are not those used for, or appropriate to, the calculation of maximum individual doses.

Table 10

CONTINENTAL POPULATION DOSES PER kCi OF ^{222}Rn RELEASED IN 1978

	Population Dose Resulting from a 1-kCi Release of ^{222}Rn During 1978, organ-rem*			
Release Site	Bronchial Epithelium	Whole Body	Pulmonary Lung	Bone
Casper, Wyoming	56.	8.8	2.0	120.
Falls City, Texas	72.	5.8	1.6	77.
Grants, New Mexico	52.	8.2	1.8	110.
Wellpinit, Washington	43.	9.0	1.7	120.
Average	56.	8.0	1.8	110.

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*Values given are based on data reported in Reference 10 and amended for inclusion in Reference 1. Exposure pathways considered include inhalation and ingestion. Isotopes considered include ^{222}Rn and its short-lived daughters, ^{210}Pb, ^{210}Bi, and ^{210}Po. A 100-year integrating period was used in the application of the environmental dose commitment concept.

Table 11

PROJECTED POPULATION OF THE UNITED STATES, 1978-2100

Year	Projected U.S. Population, millions*	Year	Projected U.S. Population, millions*
1978	218.4	1992	247.4
1979	220.2	1993	249.3
1980	222.2	1994	251.1
1981	224.2	1995	252.8
1982	226.3	1996	254.4
1983	228.5	1997	255.9
1984	230.7	1998	257.5
1985	232.9	1999	258.9
1986	235.1	2000	260.4
1987	237.2	2025	287.5
1988	239.4	2050	291.1
1989	241.5	2075	291.9
1990	243.5	2100	293.0
1991	245.5		

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*Population projections through the year 2000 are from Reference 18. Later projections were obtained from Reference 10 and are based on a predicted growth rate obtained from Reference 19.

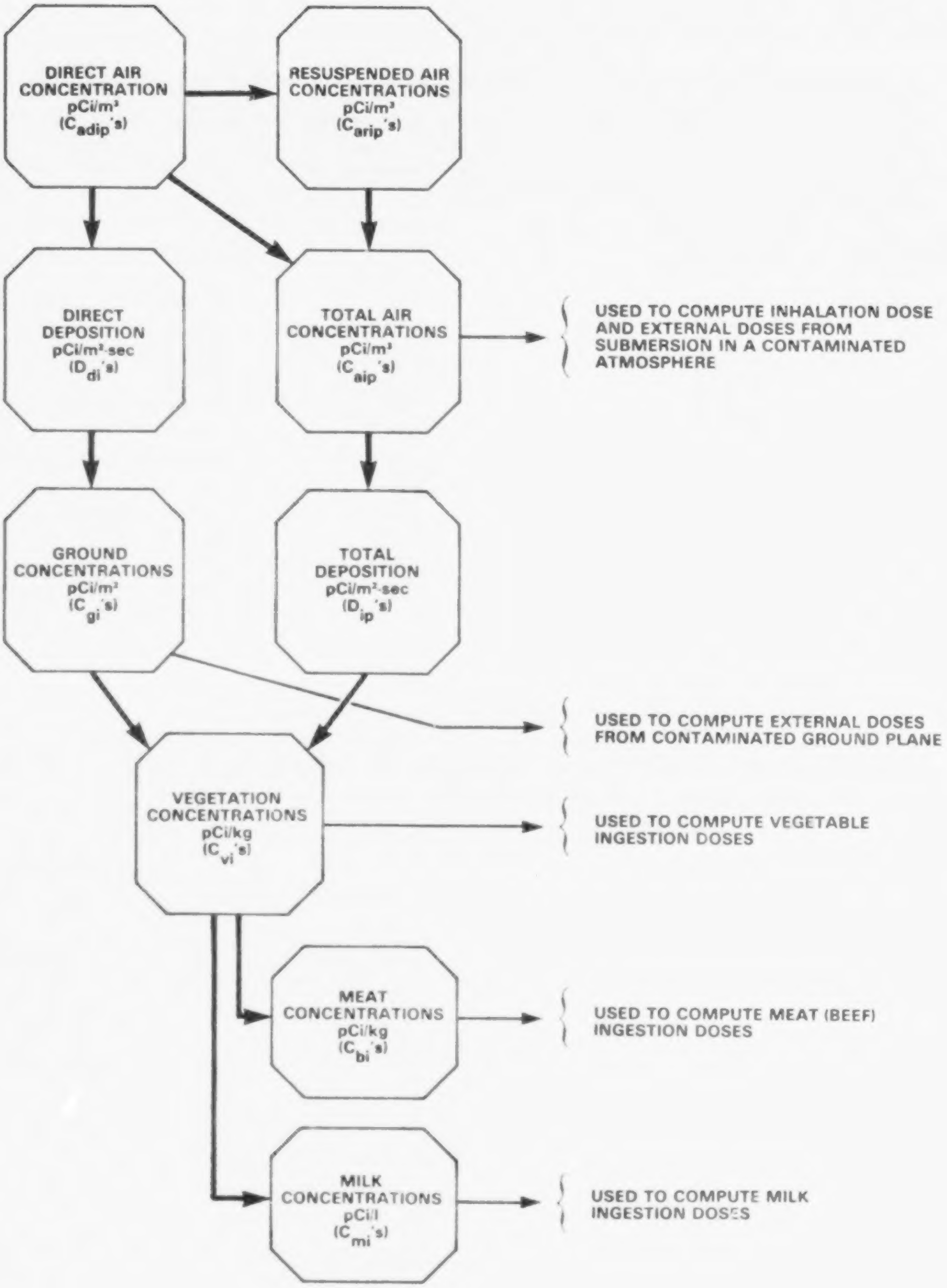
DIRECT AIR CONCENTRATION pCi/m³ (C_{adip}'s)
RESUSPENDED AIR CONCENTRATIONS pCi/m³ (C_{arip}'s)
DIRECT DEPOSITION pCi/m²-sec (D_{di}'s)
TOTAL AIR CONCENTRATIONS pCi/m³ (C_{aip}'s)
USED TO COMPUTE INHALATION DOSE AND EXTERNAL DOSES FROM SUBMERSION IN A CONTAMINATED ATMOSPHERE
GROUND CONCENTRATIONS pCi/m² (C_{gi}'s)
TOTAL DEPOSITION pCi/m²-sec (D_{ip}'s)
USED TO COMPUTE EXTERNAL DOSES FROM CONTAMINATED GROUND PLANE
VEGETATION CONCENTRATIONS pCi/kg (C_{vi}'s)
USED TO COMPUTE VEGETABLE INGESTION DOSES
MEAT CONCENTRATIONS pCi/kg (C_{bi}'s)
USED TO COMPUTE MEAT (BEEF) INGESTION DOSES
MILK CONCENTRATIONS pCi/l (C_{mi}'s)
USED TO COMPUTE MILK INGESTION DOSES

Figure 1. Schematic Diagram of Information Flow and Use For Dose Calculations

Table 12

CONVERSION FACTORS INTO SI UNITS

	Old Units*	New SI Units	Conversion Factor from Old to New Units
Activity Concentrations (Environmental)			
Airborne Particulates and Gas	$pCi \cdot m^{-3}$	$Bq \cdot m^{-3}$	3.70E-02
Liquids (Water, Milk, etc.)	$pCi \cdot L^{-1}$	$Bq \cdot L^{-1}$	3.70E-02
Solids (Soil, Sediment, Vegetation, Food Stuff, etc.)	$pCi \cdot kg^{-1}$	$Bq \cdot kg^{-1}$	3.70E-02
Activity Concentrations (Effluent)			
Gas (Air)	$(\mu Ci \cdot mL^{-1})$**	$Bq \cdot m^{-3}$	3.70E+10
Liquid	$(\mu Ci \cdot mL^{-1})$**	$Bq \cdot L^{-1}$	3.70E+07
Exposure Rate (Environmental)	$\mu R \cdot h^{-1}$	$C \cdot kg^{-1} \cdot h^{-1}$	2.58E-10
Absorbed Dose	mrad	Gy	1.00E-05
Dose Equivalent	mrem	Sv	1.00E-05
Dose Equivalent Rate (Commitment)	$mrem \cdot yr^{-1}$	$Sv \cdot yr^{-1}$	1.00E-05

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*Sanctioned for temporary use.

**Adopted because of established convention and use in maximum permissible concentration (MPC) tabulations.

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SYMBOLS

Symbol	Description
a	Equal to $(t - 1.82)$ if $t > 1.82$ and otherwise equal to zero in yr
A_s	Area of segment s in km^2
B_{vi}	Soil-to-plant transfer coefficient for radionuclide i and vegetation type v, (pCi/kg(wet) plant per pCi/kg(dry) soil)
C_{adip}	Calculated direct air concentration of radionuclide i in particle size p resulting from operational releases in pCi/m^3
C_{ai}	Total air concentration of radionuclide i in pCi/m^3
$C_{aip}(t)$	Calculated total air concentration of radionuclide i in particle size p at time t in pCi/m^3
$C_{arip}(t)$	Calculated resuspended air concentration of radionuclide i in particle size p at time t in pCi/m^3
$C_{arip}(T_d)$	Residual resuspended air concentration of radionuclide i in particle size p resulting from operational releases at the end of the T_d-year drying period in pCi/m^3
C_{bi}	Resulting average concentration of radionuclide i in meat in pCi/kg
C_{fis}	Concentration of radionuclide i in food category f in segment s in pCi/kg(wet weight)
$C_{gi}(t)$	Calculated ground surface concentration of radionuclide i at time t in pCi/m^2
$C_{gi}(T_d)$	Residual ground concentration of radionuclide i resulting from operational releases at the end of the T_d-year drying period in pCi/m^2
$C_{gi}(T_o)$	Ground concentration of radionuclide i at the time of mill shutdown in pCi/m^2
$C_{g12}(Pb \leftarrow Ra)$	Incremental ^{210}Pb ground concentration resulting from ^{226}Ra deposition in pCi/m^2
C_{hi}	Concentration of radionuclide i in hay (or other stored feed) in pCi/kg(wet weight)
C_{mi}	Resulting average concentration of radionuclide i in milk in pCi/L

SYMBOLS (Continued)

C_{pgi}	Concentration of radionuclide i in pasture grass in pCi/kg (wet weight)
C_{vi}	Resulting concentration of radionuclide i in vegetation v in pCi/kg(wet weight)
C_{vis}	Average concentration of radionuclide i in vegetable type v produced in segment s in pCi/kg(wet weight)
$C_{vis}(avg)$	Average concentration of radionuclide i averaged over all types of vegetables in segment s in pCi/kg(wet weight)
$DCF_{ij}(cld)$	Dose conversion factor for cloud exposure from radionuclide i to organ j in mrem/yr per pCi/m^3
$DCF_{ij}(gnd)$	Dose conversion factor for ground exposure from radionuclide i to organ j in mrem/yr per pCi/m^2
$DCF_{ijk}(ing)$	Ingestion dose conversion factor for radionuclide i in organ j of an individual in age group k in mrem/pCi ingested
$DCF_{ijp}(inh)$	Inhalation dose conversion factor for radionuclide i, organ j, and particle size p in mrem/yr per pCi/m^3
D_{di}	Resulting direct deposition rate of radionuclide i in pCi/m^2 per sec
D_i	Total deposition rate, including deposition of resuspended activity, of radionuclide i in pCi/m^2 per sec
$d_j(ext)$	External dose to organ j in mrem/yr
$d_j(inh)$	Inhalation dose to organ j in mrem/yr
$d_{jk}(ing)$	Ingestion dose for organ j of an individual in age group k in mrem/yr
$d_{jk}(tot)$	Total dose to organ j of an individual in age group k from all exposure pathways in mrem/yr
$d_{js}(ext)$	Average external dose to organ j in segment s in mrem/yr
$d_{js}(inh)$	Average inhalation dose to organ j in segment s in mrem/yr
E_f	Factor to account for activity remaining after food preparation, dimensionless
E_v	Fraction of the foliar deposition reaching edible portions of vegetation v, dimensionless

SYMBOLS (Continued)

F_{bi}	Feed-to-meat transfer coefficient for radionuclide i, in pCi/kg per pCi/day ingested (see Table 2)
F_{fk}	Fraction of the production of food type f ingested by individuals in age group k, dimensionless
F_{mi}	Feed-to-milk transfer coefficient for radionuclide i in pCi/L per pCi/day ingested (see Table 2)
F_{pg}, F_h	Fractions of the total annual feed requirement assumed to be satisfied by pasture grass or locally grown stored feed (hay), respectively, dimensionless
F_{pk}	Fraction of the regional population belonging to age group k, dimensionless
F_r	Fraction of the total deposition retained on plant surfaces, 0.2, dimensionless
G_{fs}	Productivity factor for food f in segment s in kg/yr per km^2
I_{ik}	Activity ingestion rate of radionuclide i by an individua in age group k in pCi/yr
M_j	Annual committed population dose to organ j in rem/yr
$M_j(d)$	Annual committed population dose to organ j during the drying phase in rem/yr
$M_j(ing)$	Resulting regional population dose from food ingestion for organ j in rem/yr
$M_j(inh + ext)$	Resulting population dose from inhalation and external exposure pathways in rem/yr
$M_j(m)$	Annual committed population dose to organ j during the milling phase in rem/yr
$M_j(m\&d)$	Aggregate committed population dose to organ j over the milling and drying phases in rem
$M_j(Rn)$	Annual continental population dose from ^{222}Rn and its daughters to organ j in rem/yr
p	Assumed soil areal density for surface mixing, 240 kg(dry weight)/m^2
P_s	Population residing in segment s
Q	Assumed feed ingestion rate at 50 kg(wet weight)/day

SYMBOLS (Continued)

Q_{fi}	Gross activity content of radionuclide i in food f in pCi/yr
$R_p(t)$	Ratio of the resuspended air concentration to the ground concentration for a ground deposit of age t yr for particle size p in m^{-1}
t	Time interval over which deposition has occurred in sec
T_d	Duration of time required to dry the tailings pile prior to reclamation in yr
T_o	Duration of the operational phase in yr
t_v	Assumed duration of exposure while vegetation v is growing in sec
U_{fk}	Average consumption rate of food type f for an individual in age group k (see Table 8 for values) in L/yr or kg/yr
U_{mk}, U_{bk}	Milk (in L/yr) and meat (in kg/yr) ingestion rates for an individual in age group k
U_{vk}	Ingestion rate of vegetable category v for age group k, in kg(wet weight)/yr
V_p	Deposition velocity of particle size p in m/sec (see Table 1)
W_{vs}	Weighting factor for vegetable type v in segment s (fraction of total production), dimensionless
Y_v	Assumed yield density of vegetation v, in kg/m^2 (wet weight)
$\delta(t)$	Zero if $t \leq 1.82$ and unity otherwise, dimensionless
λ_e	Assumed rate constant for environmental loss in sec^{-1}
λ_i	Radioactive decay constant for radionuclide i in sec^{-1}
λ_i^*	Effective removal constant for radionuclide i on soil in yr^{-1}
λ_n^*	Effective rate constant for loss by radioactive decay and migration of a ground-deposited radionuclide and equal to $\lambda_n + \lambda_e$ in sec^{-1}
λ_R	Assumed decay constant of the resuspension factor (equivalent to a 50-day half-life), 5.06 yr^{-1}
λ_w	Decay constant accounting for weathering losses (equivalent to a 14-day half-life), 5.73×10^{-7} sec^{-1}

VALUES OF CONSTANTS

Terminal value of the resuspension factor for particles with a deposition velocity of 0.01 m/sec	$10^{-[illegible]}$ m^{-1}
Initial value of the resuspension factor for particles with a deposition velocity of 0.01 m/sec	$10^{-5}m^{-1}$
Deposition velocity for the particle size for which the initial resuspension factor value is 10^{-5}/m	0.01m/sec
Fraction of vegetable activity remaining after food preparation, dimensionless	0.5
Effective reduction factor because of structural shielding for indoor exposure periods	0.825
Time required to reach the terminal resuspension factor	1.82 yr

APPENDIX A

SITE-SPECIFIC INFORMATION AND DATA USED BY THE NRC STAFF IN PERFORMING RADIOLOGICAL IMPACT EVALUATIONS FOR URANIUM MILLING OPERATIONS

Table A-1 lists and partially describes most of the information and data commonly used by the NRC staff in performing its uranium mill radiological impact evaluations. All the data detailed in Table A-1 are not always available on a site-specific basis, in which case the staff will employ conservative estimates or assumptions. In some situations, the data identified in Table A-1 may not be adequate, so the staff will attempt to secure additional information. This situation may arise, for instance, when operations at more than one site are involved and the staff is required to evaluate combined impacts. In most cases, however, provision of the data identified in Table A-1 allows the staff to completely fulfill its responsibilities with regard to the preparation of a thorough, knowledgeable, and technically sound radiological impact evaluation.

Table A-1

PLANT, PLANT OPERATIONS, METEOROLOGICAL, AND ENVIRONMENTAL DATA ROUTINELY USED BY THE NRC STAFF IN PERFORMING RADIOLOGICAL IMPACT EVALUATIONS

I. PHYSICAL PLANT DATA

A. Detailed site plot plan (overlaid on topographic map with scale and true north arrow) clearly identifying all locations of--

1. Site property boundaries
2. Raw ore storage pads
3. Primary crushers
4. Secondary crushers
5. Crushed ore storage areas
6. Ore grinders
7. Yellowcake dryer and yellowcake dryer stack*
8. Yellowcake packaging area and exhaust stack
9. Tailings impoundments and their boundaries
10. Any heap leach piles and their boundaries
11. Restricted area boundaries if different from site property boundaries
12. Fences

B. Plant operations data

1. General data

   a. Ore processing rates for all crushers and grinders, MT/d; hr/d and d/yr operational
   b. Raw ore grade, % U_3O_8 by weight, average and range
   c. Fractions of uranium, thorium, radium, and lead in raw ore expected to flow through to tailings
   d. Expected yellowcake purity, % U_3O_8 by weight, average and range, MT/yr produced
   e. Expected calendar years of initial ore milling, final ore milling, and completion of tailings area reclamation

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*Part of the input to the NRC staff's impact assessment computer code consists of X, Y, and Z coordinates for various release and receptor locations. The staff routinely determines these coordinates with respect to the topographic elevation at the location of the yellowcake dryer stack. A list of all such locations should be given in the radiological assessment.

Table A-1 (Continued)

2. Ore storage data

   a. Areas of each pile or bin complex, m^2
   b. Ore storage masses
   c. Ore grades, % U_3O_8 by weight
   d. Antidusting measures routinely implemented
   e. Anticipated dusting rates, MT/yr
   f. Anticipated ^{222}Rn releases, Ci/yr
   g. Fractions of input ore sent to storage

3. Crushing, grinding data

   a. Description of ventilation air filtration equipment
   b. Design efficiency of exhaust filters
   c. Minimum efficiencies of exhaust filters
   d. Filter testing procedure and schedule if applicable
   e. Fraction of time filters not operational or used
   f. Any measured effluent concentrations
   g. Stack heights and airflows
   h. Anticipated release rates, kg/hr or kg/MT yellowcake processed
   i. Anticipated ^{222}Rn release rate, Ci/yr
   j. Fractions of ore throughput reaching filters as dust

4. Yellowcake drying and packaging data

   a. Processing rates, MT/hr, for drying and packaging if different
   b. Hr/d and d/yr drying and packaging operations are carried out
   c. Description of all ventilation air filtration equipment with design, expected, and minimum efficiencies
   d. Filtration equipment testing procedures and frequencies
   e. Any measured effluent concentrations
   f. Stack heights and airflows
   g. Anticipated release rates, kg/hr, for the dryer stack, the packaging area ventilation exhaust, and any yellowcake storage area ventilation exhausts
   h. Annual yellowcake yield, MT/yr

5. Tailings impoundment system (including evaporation or settling ponds) data

   a. Complete physical, chemical, hydrological, and radiological description
   b. Total area, surface areas expected to be under water, saturated, moist, and dry (indicate surface moisture contents used as basis of estimates)

Table A-1 (Continued)

- c. Description of antidusting measures routinely implemented and their expected effectiveness
- d. Anticipated dusting rates for saturated, moist, and dry surface areas, g/m^2 per sec
- e. Anticipated ^{222}Rn release rates for underwater, saturated, moist, and dry surface areas, Ci/yr per m^2
- f. Estimated drying time required prior to initiation of reclamation procedures and basis
- g. Estimated time required to stabilize and reclaim after drying and basis
- h. Postreclamation estimated ^{222}Rn release rate, Ci/yr per m^2, and basis

II. METEOROLOGICAL DATA

- A. Joint frequency data
  - 1. National Weather Service (NWS) station data
    - a. Locations of all NWS stations within 80 km (50 mi)
    - b. Available joint frequency distribution data by wind direction, wind speed, and stability class (3-dimensional numerical array)
    - c. Period of record by month and year
    - d. Height of data measurement
  - 2. Onsite meteorological data
    - a. Location and heights of instrumentation
    - b. Description of instrumentation
    - c. Minimum of 1 full year of onsite joint frequency distribution data broken down by wind direction, wind speed, and stability class (3-dimensional array) with a joint data recovery of 90 percent or more
- B. Miscellaneous data
  - 1. Annual average mixing depth heights
  - 2. Description (general) of regional climatology, particularly including frequencies and durations of extreme wind speeds

III. ENVIRONMENTAL DATA

- A. A detailed topographic map of the area within 8 km (5 mi) of the site showing the locations of all--
  - 1. Site boundaries
  - 2. Lands owned, leased, or otherwise controlled (including mill site claims) by the applicant

Table A-1 (Continued)

3. Lands privately owned
4. Lands under the jurisdiction of the U.S. Bureau of Land Management
5. Lands otherwise publicly held
6. Lands useable and available for grazing
7. Private residences or other structures used by the general public
8. Vegetable or other crops, identified by type
9. Private, public, and industrial water wells and natural springs
10. Milk animals (cows or goats)

B. Regional data (within 80 km)

1. Population distributions by direction (16) and radius (for 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km) for a recent year (no earlier than 1970), for the last year of expected milling (approximate), and for the last year prior to completion of tailings area reclamation (approximate) with expected age group fractions (if available)

2. Available county food production data, kg/yr, for vegetables (by type and totals), meat (all types), and milk; any available future predictions by local governmental, industrial, or institutional organizations

APPENDIX B

STAFF METHODOLOGY FOR THE COMPUTATION OF 100-YEAR ENVIRONMENTAL DOSE COMMITMENTS

A primary objective of the NRC staff's radiological impact analysis is to estimate the aggregate radiological impact of the evaluated facilities. In attempting to achieve this goal, the staff employs the concept of environmental dose commitment (EDC) and uses an integrating period of 100 years. In adopting this general calculational approach, the staff has also endeavored to select and employ a specific calculational scheme suitable for routine use, both by the NRC staff and by uranium milling license applicants. The specific technique used by the staff is, for this reason, greatly simplified but somewhat less comprehensive in comparison with other published approaches for EDC computation. This appendix describes the staff's technique for EDC evaluation and addresses the rationale for selecting a 100-year integrating period.

Ordinarily, to compute maximum individual doses, the staff uses environmental concentrations calculated for the final year of the particular phase of milling operations. The duration of the operational (milling) phase is most often estimated to be 15 to 20 years, while drying of tailings piles in the prestabilization phase may require from 2 to 5 years or slightly longer. The lengths of these time intervals define the value of the time variable "t" that appears in Equations 2, 3, 4, and 6 of Regulatory Position 1, Concentrations in Environmental Media, of this guide.

The staff technique for evaluating regional population EDCs for an integrating period of 100 years following activity release involves artificially setting the value of t to 101 years. The specific procedural steps taken by the staff in the calculation of 100-year EDCs are then as otherwise described in Regulatory Positions 1 and 3 and as follows:

1. Obtain all necessary input direct air concentrations, as identified in Table 1 of the guide, for average release rates (by radionuclide) over the time interval of the phase being evaluated.

2. Evaluate all required environmental media concentrations by means of the equations provided for this purpose in Regulatory Position 1, using a value of 101 years for the variable t appearing in Equations 2, 3, 4, and 6.

3. Based on the environmental media concentrations computed for t = 101 years, using appropriate population, agricultural, and other data as described in Regulatory Position 3, calculate the regional population doses for all exposure pathways for an exposure period of 1 year.

4. Sum the computed doses, as appropriate, over all exposure pathways.

These calculational procedures actually result in the computation of the population dose commitments resulting from a 1-year exposure period to environmental concentrations existing during the 101st year of releases at the constant rates employed. The similarity of this result to the desired EDC (the population dose commitments resulting from a 100-year period of exposure to environmental concentrations resulting from constant releases over a 1-year time period) is illustrated in Table B-1, which provides a comparison of staff and conventional methodologies for EDC computation. This table has been organized to display the component parts of each calculational method. Line-by-line equivalence of these component parts can be readily demonstrated under conditions of constant population, population distribution, and agricultural productivity in the site region.

The staff has elected to use the approach described, rather than the more conventional approach, and a 100-year integrating period, primarily for the following reasons:

1. The major exposure pathways are dominated by doses resulting from airborne activity, which decreases rapidly in the absence of a continuing source (the resuspension factor has a half-life of about 50 days);

2. The major dose impact of ground concentrations arises from the food ingestion pathways, which depend on estimates of agricultural productivity (forecast data for food productivity in specific areas are rare and are considered to be potentially unreliable);

3. Inordinate computational difficulties are involved in routinely taking into account growth trends not amenable to description by very simple mathematical functions; and

4. The vast majority of resulting population exposure results from environmental concentrations at distances between 20 and 80 km (32 and 50 mi) from the site at which routine atmospheric dispersion calculations cannot generally yield results with sufficient accuracy to justify accounting for minor perturbations.

Table B-1

COMPARISON OF STAFF AND CONVENTIONAL TECHNIQUES FOR ENVIRONMENTAL DOSE COMMITMENT CALCULATION

	NRC Staff EDC Calculational Technique* (Defined as population dose commitments resulting from a 1-year period of exposure to environmental concentrations present during the 101st year of constant releases)			Conventional EDC Calculational Technique (Defined as population dose commitments resulting from a 100-year period of exposure to environmental concentrations resulting from constant releases over a 1-year period)		
Line	Exposure Interval, yr	Release Interval, yr	Average Time Difference, yr	Exposure Interval, yr	Release Interval, yr	Average Time Difference, yr
1	100 - 101	100 - 101	0	0 - 1	0 - 1	0
2	"	99 - 100	1	1 - 2	"	1
3	"	98 - 99	2	2 - 3	"	2
4	"	97 - 98	3	3 - 4	"	3
5	"	96 - 97	4	4 - 5	"	4
6	"	95 - 96	5	5 - 6	"	5
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
94	"	7 - 8	93	93 - 94	"	93
95	"	6 - 7	94	94 - 95	"	94
96	"	5 - 6	95	95 - 96	"	95
97	"	4 - 5	96	96 - 97	"	96
98	"	3 - 4	97	97 - 98	"	97
99	"	2 - 3	98	98 - 99	"	98
100	"	1 - 2	99	99 - 100	"	99
101	"	0 - 1	100	100 - 101	"	100

---

*This table has been purposely organized to portray a line-by-line similarity between staff and conventional EDC computation methods. Computation by both methods is broken down into component parts that, under conditions described in the text, can be shown to be mathematically identical.

APPENDIX C

RADON DOSE CONVERSION FACTOR

The basis on which the NRC staff has relied for its radon daughter inhalation dose conversion factor consists of the following major component parts:

1. The indoor working level (WL) concentration resulting from an outdoor ^{222}Rn concentration of 1 pCi/m^3 is approximately 5.0×10^{-6} WL.

2. The number of cumulative working level months (WLM) exposure per year for an average individual at a constant concentration of one WL is 25 WLM/yr.

3. The committed dose equivalent to the bronchial epithelium (basal cell nuclei of segmented bronchi) per unit WLM exposure is 5000 mrem (5 rem).

These component parts enter into the following equation, which yields the ^{222}Rn inhalation dose conversion factor used by the staff:

$$\frac{5.0 \times 10^{-6}\ \text{WL}}{\text{pCi/m}^3} \times \frac{25\ \text{WLM/yr}}{\text{WL}} \times \frac{5000\ \text{mrem}}{\text{WLM}} = \frac{0.625\ \text{mrem/yr}}{\text{pCi/m}^3}$$

Each of the three components identified above are derived from the following sources and data:

1. 5×10^{-6} WL per pCi/m^3 of ^{222}Rn is established by the assumed indoor air concentration ratios for ^{222}Rn, ^{218}Po, ^{214}Pb, and ^{214}Bi of 1.0/0.90/0.51 and 0.35. These concentration ratios and the derived conversion factor are representative of conditions in a reasonably well-ventilated structure (Refs. 1 and 2 for Appendix C).

2. 25 WLM/yr per WL concentration is derived from the assumption that an average individual's average breathing rate will be about 50 percent of that of a working miner. A WLM is defined, in terms of exposure to a working miner, as one month's occupational exposure to a 1-WL concentration. This assumed breathing rate would result in an average individual receiving about

0.5 WLM as a result of the same length of exposure to air at a 1-WL concentration. The following relationship applies:

$$(8760\ \text{hr/yr}) \times \frac{12\ \text{WLM/yr-WL}}{40\ \text{hr/wk} \times 52\ \text{wk/yr}} \times 0.5 = 25\ \text{WLM/yr-WL}$$

3. Five rem/WLM is the value derived from applying a quality factor (QF) of 10 for alpha radiation to convert from rad to rem (Refs. 1, 2, and 3 of Appendix C) to the figure of 0.5 rad/WLM as reported in the BEIR Report (page 148 of Ref. 3 of Appendix C).

The NRC staff considers the above basis for its ^{222}Rn inhalation dose conversion factor to be both sound and reasonable. The staff acknowledges that radon dosimetry is extremely complex and strongly influenced by assumed environmental and biological conditions. In view of the large variations induced by rather small changes in the assumed free-ion fraction, relative equilibrium, thickness of the intervening tissue and mucous layers, etc., the staff has endeavored to use physical, environmental, and other data reasonably representative of average conditions.

REFERENCES FOR APPENDIX C

1. Environmental Protection Agency, "Potential Radiological Impact of Airborne Releases and Direct Gamma Radiation to Individuals Living Near Inactive Uranium Mill Tailings Piles," EPA Report EPA-520/1-76-001, January 1976.

2. Environmental Protection Agency, "Environmental Analysis of the Uranium Fuel Cycle, Part I--Fuel Supply," EPA Report EPA-520/9-73-003-B, October 1973.

3. National Academy of Sciences--National Research Council, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Report of the Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR), November 1972.

VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

The proposed action consists of the development and publication of a routine methodology for assessing the radiological impacts of routine radioactive releases from uranium mills. These radiological impacts include doses to exposed individuals, doses to the population within an 80-km (50-mi) radius, doses to the population of the entire United States, and doses to the population of the North American Continent. Evaluations made using the published methodology would serve several regulatory and licensing purposes for which the methodology must be suitable. These purposes include evaluating compliance with 40 CFR Part 190 and NRC regulations, evaluating impacts of releases as part of the overall ALARA evaluation, and evaluation of environmental impacts to meet NEPA requirements.

1.2 Need

Radiological impact evaluations for routine releases from uranium mills have been carried out in the past, and numerous new and repeat evaluations will probably be required in the future. Past evaluations have been prepared by NRC personnel or by personnel from national laboratories under contract. These assessments have lacked a uniformity of approach and purpose for numerous reasons, the most important being the absence of a standardized routine procedure. Other reasons include, but are not limited to, the evolution of new models, techniques, and data; the development of new concerns requiring new methods of analysis; and the problems associated with having evaluations prepared by different groups of people. This situation needed to be corrected. The proposed action includes the publication of state-of-the-art analytical models, including environmental transport models and data, models and data for human dosimetry, and appropriate data for receptor characteristics. An example of the problems to be addressed by this effort is the evaluation of the long-term time-integrated impact of mill tailings piles, heretofore assessed by NRC only in terms of the impact during a single year.

1.3 Value/Impact

1.3.1 NRC

The document conveying the results of the proposed action will be a useful tool and should result in substantial benefits to NRC. These include upgrading the quality of future evaluations, particularly with regard to uniformity, completeness, and the application of more up-to-date methods and data. Other benefits will include greater flexibility in personnel assignments and reduced allocations of personnel time to completing evaluations.

1.3.2 Other Government Agencies

Other agencies will have available a reliable reference document explaining NRC's evaluation techniques. If evaluations can be conducted more uniformly, other agencies concerned with radiological and health impacts would benefit from these evaluations as they become more familiar with a routine approach and require less time to review NRC evaluations.

1.3.3 Industrial and Public Interest Groups

Clearly predictable impacts on these groups include the costs involved in familiarizing themselves with the proposed regulatory guide. Benefits will be derived from more easily predicting and understanding the results of NRC evaluations. Some differences from past evaluation techniques have been incorporated in this guide, but based on public comment, the degree and effects of such alterations appear to be minimal.

1.3.4 Public

The public will derive a benefit from the availability of a reference document explaining NRC evaluation techniques, and a further benefit will be derived from the increase in quality of NRC evaluations and subsequent licensing decisions and regulatory requirements.

2. TECHNICAL APPROACH

The technical approach to be used is based in part on contract work prepared by staffs of the Argonne National Laboratory, the Pacific Northwest Laboratory, and the Oak Ridge National Laboratory. This approach reflects techniques currently being adopted for use in review of uranium milling license applications and license renewal applications by the Office of Nuclear Material Safety and Safeguards. Comments on the technical approach were solicited by the issuance of Draft Regulatory Guide RH 802-4 for public comment. The comments received were evaluated and modifications were made to the guide where appropriate.

3. PROCEDURAL APPROACH

In its preliminary value/impact assessment, the staff considered several procedural approaches for carrying out the proposed action and selected the publication of a regulatory guide.

4. STATUTORY CONSIDERATIONS

4.1 NRC Authority

The product document establishes routine procedures by which NRC will evaluate radiological impacts of routine airborne releases from uranium mills. These evaluations will be and are being used in "as low as is reasonably achievable" determinations to evaluate compliance with NRC regulations, to evaluate compliance with EPA's 40 CFR Part 190 regulation, and to evaluate environmental impacts as part of NRC's overall NEPA determination.

4.2 Need for NEPA Assessment

The proposed action on calculational models did not require an environmental impact statement as it was not "a major Commission action significantly affecting the quality of the environment" as detailed in paragraph 51.5(a)(10) of 10 CFR Part 51.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

No potential conflicts with other agencies have been identified. However, the proposed regulatory guide will be a principal tool in the implementation of EPA regulation 40 CFR Part 190. Implementation of 40 CFR Part 190 is an NRC responsibility.

There is some possibility that backfitting requirements may result from implementation of 40 CFR Part 190. Such possible requirements will not result from the proposed action, but rather from the EPA regulation.

6. SUMMARY AND CONCLUSIONS

Guidance on routine procedures for evaluating the radiological impact of routine airborne releases of radioactive material from uranium mills should be developed and published in a regulatory guide.

6-2/3.52

U.S. NUCLEAR REGULATORY COMMISSION

July 1982

REGULATORY GUIDE

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REGULATORY GUIDE 3.52
(Task FP 716-4)

STANDARD FORMAT AND CONTENT FOR THE HEALTH AND SAFETY SECTIONS OF LICENSE RENEWAL APPLICATIONS FOR URANIUM FUEL FABRICATION PLANTS

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

Copies of issued guides may be purchased at the current Government Printing Office price. A subscription service for future guides in specific divisions is available through the Government Printing Office. Information on the subscription service and current GPO prices may be obtained by writing the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Publications Sales Manager.

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INTRODUCTION

Section 70.33 of 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," specifies that applications for renewal of licenses to possess and use special nuclear material (SNM) in uranium fuel fabrication plants should be filed in accordance with §§ 70.21 and 70.22, which identify the general information required. The "Standard Format and Content for the Health and Safety Sections of Renewal Applications for Uranium Fuel Fabrication Plants" (hereinafter "Standard Format") was prepared to provide more specific guidance for the preparation of renewal applications. The NRC staff suggests the use of this Standard Format for renewal applications to facilitate their efficient preparation by licensees and their timely and uniform review by the NRC staff.

As specified in § 70.33, information contained in previous applications, statements, or reports filed with the Commission under the license may be incorporated by reference, provided such references are clear and specific. The information called for in this regulatory guide that is incorporated by reference to a previous application should be briefly summarized. A timely renewal application must be filed in proper form not less than 30 days prior to expiration of the existing license. However, the NRC suggests that earlier filing is preferable.

The renewal application for the health and safety section of the license consists of two major parts. The first part contains the proposed license conditions that state what performance requirements the applicant is committed to. The second part contains detailed safety information and descriptive information on how the applicant will demonstrate adherence to the conditions of the first part. This format is designed to separate the requirements in Part I (license conditions) from the descriptive information in Part II (demonstration and performance record).

The information in Part I should be written so as to be inspectable or verifiable by the NRC Office of Inspection and Enforcement. The information in Part II, on the other hand, is of major importance to the NRC staff during the review of the license renewal application and should provide the basis for licensing decisions. This Standard Format is acceptable to the NRC staff, but conformance is not required. Renewal applications with different formats will be acceptable to the staff if they provide an adequate basis for the findings required for the issuance of a license.

The following subjects are not covered by this Standard Format: SNM accounting and control, records and inspections, physical protection of plants and materials, safeguards contingency plans, packaging for transport, and transportation of SNM. These items should be part of separate submittals but should be referenced where appropriate. Standard formats and guidance for most of these subjects are found in the following regulatory guides:

4.16 - Measuring, Evaluating, and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Nuclear Fuel Processing and Fabrication Plants

5.45 - Standard Format and Content for the Special Nuclear Material Control and Accounting Section of a Special Nuclear Material License Application (Including That for a Uranium Enrichment Facility)

5.52 - Standard Format and Content for the Physical Protection Section of a License Application (for Facilities Other Than Nuclear Power Plants)

5.55 - Standard Format and Content of Safeguards Contingency Plans for Fuel Cycle Facilities

5.59 - Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance

5.60 - Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material in Transit

The Environmental Report is submitted by the applicant as a separate report and should be referenced in the introductory section of the renewal application. The analysis results should be summarized where appropriate, and the license conditions pertaining to the environment should be stated in Part I of the renewal application.

As the nuclear industry develops, the Commission's requirements for information needed in its review of applications for licenses to process and use SNM in uranium fuel fabrication plants may change. The contents of this Standard Format will be revised to reflect rule changes. Revisions of the Commission's needs for the information in connection with licensing will be conveyed to the industry and the public in the following principal ways: (1) by revisions to this Standard Format, (2) by the issuance of new or revised regulatory guides, (3) by public announcements, and (4) by direct communications to the applicant from the NRC staff as needed.

Purpose and Applicability

This Standard Format has been prepared to identify the type and quality of information needed in an application for license renewal. It is recognized that the physical size, process scope (chemical or mechanical), and plant capacity all have a bearing on the complexity and level of license application detail. Therefore, this regulatory guide is written to cover a model plant and the actual submittal may be more or less detailed. If additional guidance is required, the applicant is invited to confer with the NRC staff prior to or during the preparation of the application.

In the renewal application, the applicant should analyze the plant in terms of potential hazards and the means, including appropriate margins of safety, employed to protect against these hazards; sufficient information should be included to allow the NRC to perform independent analysis to confirm conclusions reached by the applicant. This analysis should include but is not limited to (1) the site and its relationship to accidents from natural phenomena; (2) operations involving radiation exposures and the application of the principle of as low as is reasonably achievable (ALARA); (3) nuclear criticality safety; (4) confinement and control of radioactive materials; (5) projected effluent quantities and concentrations and effluent treatment; (6) reliability of the systems essential to safety; (7) prevention and control of fire and explosion and radiological contingency planning; and (8) environmental impact associated with normal operations, abnormal conditions, and accidents.

The renewal application should demonstrate the degree of skill, care, and effort used by the applicant in operating the licensed facility. To this end, the applicant may provide in-depth analyses as supplemental reports incorporated in the application by clear and specific references. Common literature or references that are readily available need not be supplied with the application.

Because of the variety of processes and designs for a uranium fuel fabrication plant, the applicant may wish to append detailed supplemental information not explicitly identified in this guide. The following are examples:

1. A glossary of definitions, unusual terms, or abbreviations used by the applicant,

2. Supplementary information regarding assumed analytical models, calculational methods, or design alternatives used by the applicant with particular emphasis on rationale and detailed examples used to develop the bases for criticality safety, and

3. Reports furnished to the applicant by consultants.

Proprietary Information

Proprietary information must be submitted separately. When submitted, it should be clearly identified and accompanied with the applicant's justifications for requesting its being withheld from public disclosure, as specified by § 2.790, "Public Inspections, Exemptions, Requests for Withholding," of 10 CFR Part 2, "Rules of Practice for Domestic Licensing Proceedings." NRC's staff review of the safety analysis should depend as much as possible on nonproprietary information.

Style and Composition

A table of contents and an index of key items should be included in each volume of the renewal application.

The applicant should strive for clear, concise presentation of the information provided in the application.

Where numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. Where appropriate, estimated limits of errors or uncertainty should be given.

Abbreviations should be consistent throughout the application and should be consistent with generally accepted usage. Any abbreviations, symbols, or special terms not in general usage or unique to the proposed plant should be defined when they first appear in the application.

Graphic presentations such as drawings, maps, diagrams, sketches, and tables should be employed where the information may be presented more clearly or conveniently by such means. Due concern should be taken to ensure that all information so presented is legible, that symbols are defined, and that scales are not reduced to the extent that visual aids are necessary to interpret pertinent items of information. These graphic presentations should be located with the section where they are first referenced and should be referred to both by their number and by the page on which they appear.

Physical Specifications

1. Paper Size

   Text pages: 8-1/2 x 11 inches

   Drawings and graphics: 8-1/2 x 11 inches preferred; however, a larger size is acceptable provided the finished copy when folded does not exceed 8-1/2 x 11 inches.

2. Paper Stock and Ink

   Suitable quality in substance, paper color, and ink density for handling and reproduction by microfilming or image-copying equipment.

3. Page Margins

   A margin of no less than 1 inch should be maintained on the top, bottom, and binding side of all pages submitted.

4. Printing

   Composition: text pages should be single spaced.

   Type face and style: should be suitable for reproduction by microfilming or image-copying equipment.

   Reproduction: may be mechanically or photographically reproduced.

5. Binding

   Pages should be punched and assembled in standard 3-hole loose-leaf binders.

6. Page Numbering

   Pages should be numbered with a Roman numeral corresponding to the part followed by a period and a digit for the chapter followed by a hyphen and a sequential number within the chapter, i.e., the third page in Chapter 4 of Part I should be numbered I.4-3. Do not number the entire report sequentially. (Note that, because of the small number of pages in many chapters, this Standard Format is numbered sequentially throughout the document.)

7. Standard Format Reference

   References to this Standard Format should be by part, chapter, and section.

8. Number of Copies

The applicant should submit twelve copies of the renewal application.

Procedures for Updating or Revising Pages

Data and text should be updated or revised by replacing pages. "Pen and ink" or "cut and paste" changes should not be used.

The changed or revised portion on each page should be highlighted by a "change indicator" mark consisting of a bold vertical line drawn in the margin opposite the binding margin. The line should be of the same length as the portion actually changed.

All pages submitted to update, revise, or add pages to the license should show the date of change. The transmittal letter should include an index page that lists the pages to be inserted and the pages to be removed. Where major changes or additions are made, pages for a revised Table of Contents should be provided.

PART I

LICENSE CONDITIONS

Part I contains the proposed license conditions that state what performance requirements the applicant is committed to. These should not contain detailed descriptive material that is more appropriate in Part II.

This part should be written to allow inspection and enforcement of the stated performance requirements.

Chapter 1 STANDARD CONDITIONS AND SPECIAL AUTHORIZATIONS

1.1 Name

The full name of the corporation or other entity should be provided. The State where it is incorporated or organized and the location of the principal office should be indicated.

1.2 Location

Provide the full address and location, including building names and numbers.

1.3 License Number and Period of Time the License is Requested for

Provide applicable license number and the date of request for renewal. The period of time that the license is requested for should be stated.

1.4 Possession Limits

The maximum quantity of SNM of each type to be used under the license should be provided. The chemical and physical form, the enrichment, and, where applicable, the isotopic content should also be provided. All other radioactive materials subject to this license should also be included (material identification, physical form, maximum curie content, etc.).

1.5 Location Where Material Will Be Used

For each type of SNM listed under Section 1.4, indicate the facilities that will be used to perform the authorized activities (see Section 1.7).

1.6 Definitions

Terminology that is not defined in standard references (e.g., ANSI N1.1-1976, "Glossary of Terms in Nuclear Science and Technology,"* or Title 10 of the Code of Federal Regulations) or that is unique to the applicant should be defined in this section.

1.7 Authorized Activities

A summary of all activities and types of processes in which the SNM and other radioactive materials subject to this license are to be used should be given in the license renewal application (the specific details are given in Chapter 16). Activities should be keyed to specific buildings if appropriate.

1.8 Exemptions and Special Authorizations

The requested specific exemptions and special authorizations that will not endanger life or property or the common defense and security should be listed in this section and justified in the appropriate subsequent section (e.g., monitor alarms, release limits, incinerator operation, offsite possession at reactor sites).

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*Available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

Chapter 2 GENERAL ORGANIZATIONAL AND ADMINISTRATIVE REQUIREMENTS

2.1 Licensee's Policy

Indicate the procedures by which the policy with regard to safety of the work place and all license requirements will be implemented. It should also be the policy of all organizational components to keep radiation exposures to employees and the general public as low as is reasonably achievable (ALARA).

2.2 Organizational Responsibilities and Authority

Identify all key positions with safety-related responsibilities and describe their functions. The licensee should provide separate lines of authority for production and safety functions. The lines of responsibility leading to top management should be indicated.

2.3 Safety Review Committees

Provide a list of all safety review committees (e.g., radiation, criticality, ALARA, fire), and indicate the decisionmaking function for each. Include, if applicable, the independent review committee for criticality safety analysis.

For each safety review committee, the purpose, charter of responsibilities, frequency of meeting, audit and inspection responsibilities, frequency of audits, membership, and reporting and recordkeeping requirements should be specified.

2.4 Approval Authority for Personnel Selection

State the management level responsible for personnel selection for all safety-related staff positions and safety review committee membership.

2.5 Personnel Education and Experience Requirements

Provide the education, training, and experience requirements for all safety-related management and staff positions and for safety review committee members.

2.6 Training

State the policy and plans for training of new and old employees in those areas related to safety.

Indicate the steps that will be taken to assure management that operational personnel understand the safety requirements of their work assignments. Define the method for evaluating the understanding of the employees in safety areas. Include the program for retraining previously trained employees.

2.7 Operating Procedures

Provide the essential aspects of the managerial system that will be used to ensure that the operating instructions related to safety will be properly implemented. Include the controls used for (a) procedures related to all activities involving special nuclear material or other radioactive material and health and safety practices; (b) the administrative practices for establishing, modifying, and implementing such procedures; and (c) the administrative controls for the use of appropriate equipment and facilities for handling special nuclear material and other radioactive material.

Describe the administrative controls that will ensure that, prior to the start of any new or changed activity or any new or changed equipment or facility involving licensed material, an independent safety review is performed and documented.

Indicate, when applicable, the frequency of procedure review and updating. The applicant should declare a commitment to conduct fissile material processing only in accordance with approved written procedures.

2.8 Internal Audits and Inspections

Internal audits are performed to determine if plant operations are conducted in accordance with applicable regulations, license conditions, licensee's policy, and written procedures. These audits should apply to radiation protection, nuclear criticality safety, fire protection, and environmental protection. Audits should be performed according to a written plan. To ensure unbiased and competent audits, qualified personnel separate from the production organization (and without direct responsibility for the function and area being audited) should be used for the audits. For each safety-related procedure, the minimum frequency of audits should be stated.

State the positions (or safety review committee) responsible for performing periodic audits. Provide the distribution for audit reports and state who has the responsibility for followup. Include the followup inspection procedure that will be used, if necessary, to ensure that corrective action is taken. Audit and inspection reports should include recommendations for corrective actions and all such action already taken on recommendations resulting from the previous audit or a prior inspection.

2.9 Investigations and Reporting of Off-Normal Occurrences

The licensee should investigate and report to NRC all events that significantly threaten or lessen the effectiveness of the health and safety provisions of the license. The applicant should identify, in a generic manner if possible, all such events to be investigated and reported, including reportable events as compiled in Regulatory Guide 10.1, "Compilation of Reporting Requirements for Persons Subject to NRC Regulations," and as described in 10 CFR Part 21, "Reporting of Defects and Noncompliance," and events that lessen the effectiveness of the health and safety provisions of the license. Appendix B to this guide, "Sample Listing of Trend Analysis Topics," is an example of a list summarizing some events that may lessen the effectiveness of health, safety, and environmental protection that should be monitored and evaluated with respect to any detrimental trends.

Indicate the person(s) responsible for conducting the investigation and documentation of reportable events, and relate this to the organizational responsibilities (see Section 2.2).

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2.10 Records

The renewal application should include a description of the system for maintaining records relating to health and safety and their retention times. Such records should include plant alterations or additions, abnormal and off-normal occurrences and events associated with radioactivity releases, criticality analyses, audits and inspections, instrument calibration, ALARA findings, employee training and retraining, personnel exposures, routine radiation surveys, and environmental surveys.

Chapter 3 RADIATION PROTECTION

3.1 Special Administrative Requirements

3.1.1 Radiation Work Permit Procedures

Radiation work permits (RWPs) are issued whenever the activity is not covered by an operating procedure and the radioactivity levels are likely to exceed the limits specified in 10 CFR Part 20. Provide the control system for the issuance and termination of the RWPs. Indicate the method for approval of the work and the method of documentation of the approach used.

3.1.2 ALARA Policy

Provide the procedures and methods of operation that are used to ensure that occupational radiation exposures are as low as reasonably achievable (ALARA). Reference should be made to Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable." Additional useful guidance may be found in Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

3.2 Technical Requirements

3.2.1 Access Control

Radiation areas should be posted as required by § 20.203 of 10 CFR Part 20. The areas should be described (step-off pads, change facilities, protective clothing, etc.) and the monitoring program for personnel exiting these controlled areas should be provided.

3.2.2 Ventilation Requirements

Provide the surveillance program of the ventilation systems used to protect the public and plant operating personnel from airborne radioactive materials.

Provide the acceptance inspection and surveillance testing program for the principal filter system (HEPA), for any auxiliary filter-equipped ventilation system, and for any scrubber systems. This program should specify which tests are required, the acceptance criteria, and the frequency of testing.*

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*For guidance refer to ERDA 76-21, "Nuclear Air Cleaning Handbook," C.A. Bunchsted, J.E. Kahn, and A.B. Fuller, March 1976; and ANSI/ASME N510-1980, "Testing of Nuclear Air Cleaning Systems." ERDA 76-21 is available from the National Technical Information Service, Springfield, Va. 22161. ANSI/ASME N510-1980 is available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

3.2.3 Instrumentation (Survey, Counting, Criticality Monitors)

State the equipment used in radiation detection (including portable survey, air, and criticality monitors, and air sampling and counting equipment). Include the method and frequency of calibration (for guidance see Regulatory Guide 8.24, "Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication"), alarm set points, and the sensitivity range and operating characteristics where applicable.

3.2.4 Internal and External Exposure

State the performance requirements of the applicant's programs and engineered systems that are provided to protect operating personnel from excessive internal and external exposure. The following programs and systems should be included:

1. Ventilation,
2. Air sampling and analysis,
3. Bioassay,
4. Protective clothing,
5. Respiratory protection,
6. Surface contamination monitoring,
7. Decontamination,
8. Emergency evacuation, and
9. Personnel monitoring (external radiation).

Performance requirements (commitments) such as action levels, corrective action to be taken, release limits, air velocity, alarm points, calibration frequency and accuracy and precision limits should be stated in terms that can be inspected and verified.

Chapter 4 NUCLEAR CRITICALITY SAFETY

4.1 Special Administrative Requirements

The applicant should provide license conditions concerning the double contingency policy. The double contingency policy states that process designs should, in general, incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. Refer to Regulatory Guide 3.4, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."

The criterion for a management decision to perform nuclear criticality analysis and the position responsible for initiating the request and authorizing the analysis should be in agreement with the license requirements.

Provide the procedure for "Posting of Limits" at each location where fissile material is handled, processed, transported, or stored. Include the information required for labeling fissile material containers.

See Chapter 2 for general administrative requirements.

4.2 Technical Requirements

Provide the license conditions used for the approach to nuclear criticality safety to be used in the design and design changes for the building, systems, equipment or components, and processes in conjunction with fissile material. Appropriate data sources should be referenced such as Regulatory Guides 3.4 and 3.41, "Validation of Calculational Methods for Nuclear Criticality Safety." Special studies should be appended to the renewal application.

Basic assumptions and design conditions that are of particular importance in the safety analysis should be listed in this section. Examples of such assumptions and design conditions are:

1. Minimizing the possibility of the accumulation of fissile materials in locations other than those specifically designed for accumulation.

2. Nuclear safety dependence on the degree of moderation within the process unit and dependence on the degree of moderation between units.

3. Nuclear safety dependence on neutron reflector thickness for the reflector of interest.

4. Nuclear safety dependence on enrichment, concentration, and diluents.

5. Optimum conditions (limiting case) of water moderation and heterogeneity credible for the system.

6. The analytical methods used for criticality safety analysis and the validation of the methods.

7. Safety margins for selected individual units and the justification of these safety margins based on normal and accident conditions such as flooding, multiple batching, and fire.

8. Safe geometry parameters applicable to the licensee's operation.

9. Method of deriving applicable multiplication factors.

10. Criteria used in spacing of pipes, process vessels, transport and process equipment, storage containers, etc.

11. Criteria for the application of fixed poisons (e.g., borosilicate raschig rings).

12. Design basis to ensure structural integrity of safety-related structures, systems, and components.

13. Criteria for preoperation testing of equipment.

14. Criteria used in the choice of fire protection methods.

Chapter 5 ENVIRONMENTAL PROTECTION

5.1 Effluent Control Systems

Action levels for gaseous and liquid effluents should be stated. These action levels should be selected so as to meet defined regulatory limits and the ALARA commitments. The anticipated action should be indicated for each event that could cause action levels to be exceeded. Regulatory Guide 4.16, "Measuring, Evaluating, and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Nuclear Fuel Processing and Fabrication Plants," and Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," may be used.

State the sampling method, frequency, radioactivity analysis, and action levels and action taken prior to discharge of all radioactive waste streams and the process cooling water. State the approximate volume and rate of discharge and indicate their destinations (e.g., municipal sewerage, local stream, general environment, storage pond).

State the sampling method, its frequency (or whether it is continuous), analysis, action levels and action, lower limits of detection, calibration and standardization of measurements, method of reporting, and responsibility for action taken for all gaseous effluents at their point of discharge.

Identify the means for the disposal of all solid contaminated equipment and materials.

Designate the positions having responsibility for effluent control and monitoring to ensure compliance with all applicable standards, rules, and license conditions.

5.2 Environmental Monitoring

Provide the radiological environmental monitoring program (which includes air and fallout sampling) for evaluating the airborne radioactivity. State the methods (e.g., thermoluminescence dosimetry) for determining ambient radiation levels for both onsite and offsite locations. In addition, provide the soil, vegetation, and surface- and underground-water sampling program. Identify the location of the sampling stations, including the background station, and the procedures for evaluating and reporting results of this monitoring program.

Provide the nonradiological monitoring program used to meet State and Federal EPA requirements, including sampling of stack gases for major air pollutants (e.g., fluorides, ammonia, NO_x) and ground waters for similar pollutants. Include the procedures for the evaluation and reporting of the results for this monitoring program. The information will be used for writing the environmental impact assessment or the environmental impact statement (EIA or EIS).

Chapter 6 SPECIAL PROCESS COMMITMENTS

In this chapter, report special procedures or actions required for unique processes or operations to ensure radiological safety, nuclear criticality safety, and fire protection (e.g., moderation control, furnace-reducing atmospheres, H_2 explosion prevention).

Special processes may contain proprietary information, which should be submitted separately in accordance with § 2.790 of 10 CFR Part 2. However, proprietary process requirements that have safety-related license conditions should be inspectable without restraint (e.g., process control limits for ammonia diuranate (ADU) conversion, fluidized bed conversion, or direct conversion of UF_6 to UO_2).

Chapter 7 DECOMMISSIONING PLAN

The renewal application should affirm the applicant's commitment to decommission the facility and the site at the end of its operation in a manner that will protect the health and safety of the public. Plans for decontaminating the facility and site so the facility and grounds can be released for unrestricted use should be provided. Details of this plan should be appended to the application. Reference may be made to NUREG/CR-1266, "Technology, Safety and Costs of Decommissioning a Reference Uranium Fuel Fabrication Plant,"* dated May 1980.

The plan should identify and discuss the factors that were considered in planning the decommissioning of the plant in sufficient detail to enable an independent review. The plan should include an estimate of the costs involved and the financial arrangements that have been or will be made to ensure that adequate funds will be available to cover these costs at the time of decommissioning.

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*Available from the National Technical Information Service, Springfield, Va. 22161.

Chapter 8 RADIOLOGICAL CONTINGENCY PLAN

The Radiological Contingency Plan should be submitted as a separate document in accordance with NUREG-0762, "Standard Format and Content for Radiological Contingency Plan for Fuel Cycle and Materials Facilities,"* dated July 1981.

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*Available from the National Technical Information Service, Springfield, Va. 22161.

PART II

SAFETY DEMONSTRATION

Part II contains detailed health and safety information on how the applicant has demonstrated adherence to the license conditions.

This part should be written to provide a basis for licensing decisions.

Chapter 9 OVERVIEW OF OPERATION

9.1 Corporate Information

Describe the corporate arrangement or organization related to the fuel fabrication activity. Provide the information required by paragraph 70.22(a)(1) of 10 CFR Part 70. If the corporation is made up of two or more existing entities, the relationship and responsibilities of each should be explained.

9.2 Financial Qualification

Provide sufficient information to demonstrate the financial capabilities for operating and decommissioning the plant. A copy of the latest corporate annual report may satisfy this requirement.

9.3 Summary of Operating Objective and Process

Describe in general terms the plant, its function and operation, its process capacity, its feed and products, and the process used.

9.4 Site Description

Provide summary information on the location of the plant and a description of the geographical, demographical, meteorological, hydrological, seismological, and geological characteristics of the site and surrounding vicinity. The objective is to indicate what, if any, site characteristics influenced plant design and mode of operation.

9.5 Location of Buildings On Site

Provide descriptive information on the buildings and other installed features of the plant and their location on the site, including identification of changes or additions.

9.6 Maps and Plot Plans

A map of the site should be included in the application and should be of suitable scale to clearly define the boundary of the site and the distance from significant facility features to the site boundary. The area to be considered as the exclusion area should be clearly delineated if its boundaries are not the same as the boundaries of the plant site. A general location map should also be provided encompassing at least an 80-km (50-mi) radius. Indicate any unusual hazard such as a dam upriver from the plant, failure of which could cause flooding at the plant site. Additional maps and site plots should be provided to present details near the plant and to establish orientation of buildings, streams, ponds, transmission lines, and neighboring structures. The State and county in which the plant is located should be identified. The location of the site relative to prominent natural and man-made features and the distance and direction to the nearest population centers should be stated.

9.7 License History

The original license issue date and subsequent renewal dates should be shown. The renewal request should include a list of all amendments granted since the previous issuance or renewal of license and also any changes in the corporate structure that may affect responsibilities under the license conditions since the previous issuance or renewal of license.

9.8 Changes in Procedures, Facilities, and Equipment

Describe the administrative controls that will ensure that, prior to the start of any new activity (or change in an existing activity) involving licensed material, an independent safety review of the proposed activity is performed and documented. It is advisable to notify the NRC of any plans to modify the licensed facility prior to ground breaking. The administrative procedure should include the following steps:

1. Assurance of Safety Review. Any proposed change in product design, manufacturing procedures, or processing equipment should be reviewed to ensure that applicable license requirements and safety considerations have been evaluated.

2. Responsibility for Requesting Safety Analysis. Indicate responsibility for selecting the proper administrative procedure to make changes in process, equipment, or procedures, e.g., (a) a revised or new radiation safety plan, safety analysis, or criticality safety study, (b) submittal to a safety review committee, or (c) an NRC license amendment.

3. Analysis. The applicant should document the comprehensive evaluation of the proposed change, including potential accidents that may affect radiation and nuclear criticality safety.

4. Review. The management positions responsible for review and approval prior to effecting a change should be identified. The review should be documented.

5. Approval. Implementation of the proposed change should take place only after final approval in writing by the designated management personnel.

6. Verification. Prior to use, an inspection should be made of approved and implemented changes. The position(s) responsible for the inspection should be indicated.

7. Records. Sufficiently detailed records to permit independent review of the analysis and approval should be maintained.

Chapter 10 FACILITY DESCRIPTION

10.1 Plant Layout

Through the use of engineering-type drawings, show the layout of the functional features of the facility. Provide plans and elevations in sufficient detail to identify all features to be discussed in this chapter. Include spatial and equipment identification data directly on the layouts with suitable designations in tabular listings.

10.2 Utilities, Including Emergency Power

Discuss the source and characteristics of the primary electrical system providing normal power to the plant.

Describe the design providing for the emergency power source(s) and the means for ensuring an uninterruptible service to those items requiring it. For each of these latter items, list the location, the equipment, and the systems serviced.

Present the general design features that make possible the restart sequence on emergency power. Also describe the general procedure for subsequent reestablishment of normal load service.

Present the design basis for supplying the compressed air needs of the plant and the air for protective masks and clothing. Describe the air systems, components, location, and operating characteristics.

Discuss the primary source of the water supply, alternative sources, storage facilities, and plant supply loops. Itemize design considerations to demonstrate a continuity of water supply. Also itemize by service (potable, process, and fire control) the quantities of water used under normal and abnormal conditions.

Discuss the effects of loss of water supply source, failure of main supply pump(s) or supply loops, and power failure.

10.3 Heating, Ventilation, and Air Conditioning

Describe the heating, ventilation, and air conditioning systems that are in support of the main process and confinement features. Emphasis should be placed on provisions for coping with unscheduled occurrences in a manner that will preclude an unsafe condition.

Describe in detail the design operating features for performance of the ventilation-filtration systems to show that there will be sufficient backup, excess capacity, repair and replacement capability, and structural integrity to ensure controlled continuous airflow in all credible circumstances to minimize the release of radioactive material. Emphasize the design features to ensure confinement of radioactive particulates under conditions of power failure, adverse natural phenomena, breakdown of equipment, fire and explosion, improper flow of air, contamination spills, and loss of filter integrity.

10.4 Waste Handling

10.4.1 Liquid Wastes

Describe how all liquid wastes are generated and enter liquid treatment systems. Include such items as laboratory wastes, liquid spills, and cleanup solutions. A statement should be made as part of the design objectives concerning the inventory levels expected, provisions for interim and long-term storage, and identification of those streams that are processed to achieve volume reduction or solidification. Relate the discussion on process and equipment to the radioactivity level.

Describe the design objectives for the system under discussion. Identify, in particular, criteria that include backup and special features to ensure that the waste will be safely contained.

Provide a description of the equipment and systems installed. Accompany the description with appropriate engineering drawings to show locations of equipment and flow paths. Describe safety-related features, systems, or special handling techniques included in the systems to ensure the safety of the operation.

10.4.2 Solid Wastes

List and characterize all solid wastes that are produced as a result of plant operation. Describe the systems used to treat, package, and contain these solid wastes.

Describe the following:

1. The methods and the equipment selected for minimizing the generation of solid wastes and for the safe management of the solid waste that is generated.

2. The equipment and associated features that are used for volume reduction, containment or packaging, storage, and disposal.

3. The procedures associated with operation of the equipment, including performance tests, process limits, and means for monitoring and controlling these limits.

4. The physical, chemical, and thermal characteristics of the solid wastes, including an estimate of concentrations and volumes generated.

5. The means for packaging the solid wastes.

For solid wastes of the type to be retained on site, show in detail the containment methods used. Discuss corrosion aspects and monitoring of the containment. Describe how these wastes will be handled at the time the plant is decommissioned.

10.5 Chemical Systems

Describe the major components and operating characteristics of facilities used for nonradioactive chemical operations. Where hazardous chemicals or materials are involved, discuss the provisions that mitigate or prevent accidents. Itemize the chemicals and materials that are used; list their quantities and where they are used and codify them with respect to hazard.

10.6 Fire Protection

List the codes and standards considered and used for the design of the buildings and the fire protection systems, including published standards of the National Fire Protection Association. Provide evidence of the adequacy of the fire protection program for the facility through nuclear liability and property insurance coverage and inspection reports.*

State the qualifications of the fire protection engineer (or consultant) who was responsible for the design of the fire protection system. Describe the design and selection of equipment, inspection and testing of the physical aspects of the system, development of the fire protection program, and the fire-fighting training for the operating plant. Include the personnel responsible for inspecting and maintaining the fire protection equipment. Describe the procedures for storage of combustibles and combustible contaminated waste.

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*It is recommended that the latest edition of the "International Guidelines for Fire Protection at Nuclear Installations," prepared by an international working party representing over 20 nuclear risk insurance pools and associations world-wide, be used. This document is available from the British Insurance Committee (Atomic Energy), Aldermary House, Queen Street, London, EC4N 1TH.

Chapter 11 ORGANIZATION AND PERSONNEL

The plan for the safe operation of the facility should be described. Sufficient detail should be provided to indicate how the applicant intends to conduct all operations to ensure that a technically competent staff will be maintained to provide continued implementation of administration and operating procedures and programs that relate to health and safety.

11.1 Organizational Responsibilities

The managerial responsibilities relative to the health and safety aspects of the facility should be described.

11.2 Organization Charts

Provide a comprehensive description of the organizational arrangement of the plant showing the title of each position, personnel occupying each position, and the flow of responsibility as depicted by an organizational chart (including the Safety Review Committee(s)).

11.3 Organizational Procedures

Describe the management policy, instructions, job descriptions, and procedures defining organizational responsibilities and authorities. Describe the responsibilities of the various management personnel and organizational units in the preparation, review, and approval of written instructions for plant operation. Describe the audit areas, responsible individuals, and the frequency of audits that will be performed in accordance with a written review and audit program.

11.4 Functions of Key Personnel

Describe the functions, responsibilities, and authorities of key personnel positions, including a discussion of specific succession to responsibility for overall operation of the plant in the event of absences, incapacitation, or other emergencies.

11.5 Education and Experience of Key Personnel

The qualifications of the key personnel assigned to the managerial and technical positions described should be presented in resumé form. The resumés should identify individuals by position and title and, as a minimum, should describe the formal education, training, and experience of the individuals.

11.6 Training

Describe the training program for new and old employees and for reinstruction when changes are made to processes involving nuclear materials, radiation protection procedures, nuclear criticality safety controls, fire protection, or emergency procedures. Specialized training for radiation protection and nuclear criticality safety should be commensurate with the extent of the employee's contact with nuclear materials.

The proposed training program should include, as appropriate, plant operational safety, ALARA practices, instrumentation and control, methods of dealing with process malfunctions, fire protection, contamination control, decontamination procedures, and emergency procedures. General subjects such as nature and source of radiation, interactions of radiation and matter, biological effects of radiation, use of monitoring equipment, and principles of nuclear criticality should also be included.

Chapter 12 RADIATION PROTECTION PROCEDURES AND EQUIPMENT

12.1 Procedures

Describe the method and plans for conducting radiation surveys and the plans that have been developed for ensuring that occupational radiation exposure will be ALARA. Describe the physical and administrative measures for controlling access to and occupancy time in radiation areas. Describe the methods for monitoring and the actions taken to control personnel exposures and equipment and surface contamination. Indicate whether, and if so how, the guidance in the following regulatory guides will be followed:

8.4 - Direct-Reading and Indirect-Reading Pocket Dosimeters
8.7 - Occupational Radiation Exposure Records Systems
8.9 - Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program
8.10 - Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable

If the complete guidance of a guide is not followed, describe the specific alternative approaches to be used.

12.2 Posting and Labeling

Describe the posting and labeling program to comply with § 20.203 of 10 CFR Part 20. Work stations and fuel storage locations should be posted with nuclear criticality safety limits and include at a minimum the following information:

1. Type and form of material permitted,
2. Allowable quantity (number of containers, pieces, weight, or volume),
3. Restrictions on presence of moderators, if required, and
4. Spacing of fissile units, if required.

The marking or label on the containers should include type of material; form; enrichment; gross, net, and tare weights; fissile material weight by isotope; and licensee's identification number.

12.3 Personnel Monitoring

Describe the personnel monitoring program to comply with § 20.202 of 10 CFR Part 20. Indicate what types of personnel monitoring equipment such as direct-reading dosimeters, alarming dosimeters, and personnel dose rate meters are used to provide early evaluation of doses to individuals and the assignment of those doses to specific operations. The type, range, sensitivity, and accuracy of the personnel dosimeters should be provided. In areas where an accidental criticality is possible, the type of dosimeter that will be used should be indicated. Describe how the dosimeter readers are routinely tested for accuracy if the personnel dosimeters are read by the licensee. The frequency of reading personnel dosimeters and the recording of the radiation dose to all individuals for whom personnel monitoring is required should be specified. Describe how dosimetry results are used as a guide to operational planning.

12.4 Surveys

Describe the routine radiation survey program as well as the special surveys taken for planning and preparing maintenance operations to ensure that occupational exposures are ALARA. Describe the bases for these activities using surveys to obtain information with respect to radiation, contamination, airborne radioactive material, and mechanical difficulties that might be encountered while performing the surveys.

12.5 Reports and Records

Reports should conform to reporting commitments as per Section 2.9 in Part I.

Describe the records that will be maintained and the required retention times. The records should include principal maintenance, alterations or additions made, abnormal occurrences and events associated with radioactivity releases, criticality analyses, audits and inspections, instrument calibration, ALARA findings, employee training and retraining, personnel exposure, routine and special radiation surveys, and environmental surveys.

12.6 Instruments

Provide the criteria for selection of portable and laboratory technical equipment and instrumentation for:

1. Performing radiation and contamination surveys,
2. Sampling airborne radioactivity, and
3. Monitoring area radiation.

Describe the selection of instrumentation and other equipment and the quantities of such equipment provided for normal plant operations to meet the anticipated needs of the plant during normal operations and during major outages that may require supplemental workers and extensive work in radiation areas.

Describe the instrument storage, calibration, and maintenance facilities. Also describe the health physics facilities and laboratory facilities for radioactivity analyses.

12.7 Protective Clothing

Describe the protective clothing available for operating personnel for normal, maintenance, and accident conditions.*

12.8 Administrative Control Levels

Describe the administrative action levels and alarm setpoints, frequency of measurements, and action to be taken for the following radiation protection monitoring programs:

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*Refer to the National Institute of Occupational Safety and Health's (NIOSH) "Certified Personnel Protective Equipment List." This is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Occupational exposure (internal and external),
2. Airborne activity (area and stack or vent monitors),
3. Liquid activity (effluent monitors),
4. Surface contamination (work areas, release of equipment or packages, skin contamination).

12.9 Respiratory Protection

To limit the inhalation of airborne radioactive materials, an acceptable respiratory protection program should be provided.

Describe the respiratory protective equipment, including a respirator fitting program, if applicable, that satisfies the guidance of Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," and NUREG-0041, "Manual of Respiratory Protection Against Airborne Radioactive Materials."*

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*Available from the National Technical Information Service, Springfield, Va. 22161.

Chapter 13 OCCUPATIONAL RADIATION EXPOSURES

13.1 Occupational Exposure Analysis

Evaluate the quarterly and annual individual occupational exposures (external and internal) for at least the past 2 years. In addition, analyze the weekly and quarterly averaged air concentration levels at work locations for at least the past 2 years.

As an appendix or addendum to the application, provide an analysis of occupational exposures (external and internal) covering at least the past 2 years of plant operation for each plant area and type of operation performed. The analysis should identify the sources and locations where most exposures occurred as related to job categories and work activities. Any trends in exposures that can be identified should be discussed. Abnormal occurrences should be reviewed and categorized by such aspects as frequency, operations being performed, and the magnitude of the resulting exposure. The analysis of internal exposures should consider air sampling data, as well as bioassay data (including in vivo counting). The analysis should conclude with a description of any steps or measures taken to reduce employee exposure, the effectiveness of these measures, and any additional actions planned.

13.2 Measures Taken To Implement ALARA

The ALARA process pertaining to radiation workers should be stated. If an ALARA committee exists, its activities should be described. The committee's membership and frequency of meetings combined with its total work scope should be stated. The procedures for performing the required audits and inspections for radiation and the administrative procedures for review of all new activities or changes in existing activities should be described.

The method by which the ALARA philosophy is implemented and assured to management should be stated. Refer to Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable." Additional useful guidance may be found in Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

A periodic report summarizing employee exposures and effluent release data should be made to senior management.

13.3 Bioassay Program

The bioassay program to detect and monitor any significant deposition of radioactive material in the body should be described. Regulatory Guides 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," and 8.11, "Applications of Bioassay for Uranium," may be used as guidance on topics such as determining (1) whether bioassay procedures are necessary, (2) which bioassay techniques to use and how often, (3) who should participate, (4) the action to be taken as based on bioassay results, (5) the particular results that should initiate such action, and (6) diagnostic evaluation. Any deviation from Regulatory Guides 8.9 and 8.11 should be justified.

13.4 Air Sampling Program

Describe the air sampling and analysis program for monitoring the concentrations of radioactivity in working areas to detect the presence of unsafe concentrations. Action levels and actions to be taken if these levels are exceeded should be specified, including the action level to shut down operations (refer to Regulatory Guide 8.24). Supply a list of types and numbers of instruments used for measuring radioactivity in air systems. Air sampling instruments should include work-area samplers, continuous air monitors, and lapel air samplers.

13.5 Surface Contamination

Identify the controlled and uncontrolled areas where the potential spread of contamination is possible. Include step-off pads, change facilities, protective clothing provided, survey meter locations, etc. Surface contamination surveys, allowable limits (fixed and removable), and action levels for immediate cleanup or delayed cleanup should be specified for clean (uncontrolled) areas, intermediate areas (e.g., change rooms), and controlled areas. The frequency of surface contamination surveys in each area should be stated (see Regulatory Guide 8.24). A list of types and numbers of instruments used for determining radiation should be supplied.

Guidance on the release of equipment and packages from the plant site is given in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,"* dated November 1976.

The personnel contamination control and radiation level survey programs, including survey frequency, instruments used (type, range, sensitivity, and accuracy), action levels, and action to be taken, should be described.

The policy on the use of protective clothing should be included.

13.6 Shipping and Receiving

Describe methods for contamination control associated with receipt, storage, handling, and shipping of containers of fissile materials. The following regulatory guides may be used for guidance:

5.57 - Shipping and Receiving Control of Strategic Special Nuclear Material
7.3 - Procedures for Picking Up and Receiving Packages of Radioactive Material
7.4 - Leakage Tests on Packages for Shipment of Radioactive Materials
8.24 - Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication

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*Available from the Nuclear Regulatory Commission, Division of Fuel Cycle and Material Safety, Uranium Fuel Licensing Branch, Washington, D.C. 20555.

Chapter 14 ENVIRONMENTAL SAFETY - RADIOLOGICAL AND NONRADIOLOGICAL

Using radiation measurements obtained from the environmental monitoring program (including sampling and analysis of river water, surface water, air, soil, and vegetation and the determination of gamma dose levels at points around the plant) during at least the past 2 years, determine the maximum annual dose equivalent to the whole body and to any other organ of any member of the public.

Summarize the nonradiological environmental impacts of gaseous and liquid effluents from the plant during the past 2 years of normal operation. Report the nonradiological gaseous and liquid concentration and release rates at the plant site boundary for the past 2 years. Reference should be made to the environmental report.

Chapter 15 NUCLEAR CRITICALITY SAFETY

15.1 Administrative and Technical Procedures

Administrative and technical procedures to ensure nuclear criticality safety in the fabrication, storage, and movement of SNM should be described in detail. Describe administrative practices such as establishing the responsibilities for nuclear criticality safety; providing qualified personnel; and establishing written criteria and procedures, process analysis, materials and operational controls, operational reviews, emergency procedures, audits and inspections, reports, acceptable data sources, and validation techniques.

15.2 Preferred Approach to Design

The preferred approach to design should be specified in this section. If the approach is other than the use of equipment of safe geometry, provide information that justifies its use. The design approach should include designs that minimize the possibility of accumulating fissile materials in inaccessible locations, make nuclear safety independent of the degree of moderation within a unit and the degree of interspersed water moderation between units, and make nuclear safety independent of neutron reflector thickness.

15.3 Basic Assumptions

The basic nuclear criticality safety analysis assumptions should be stated in the application. Some examples are maximum credible fissile material density, the optimum (limiting case) conditions of water moderation and heterogeneity credible for the system, the enrichment, and unit limits based on full reflection if such reflection is credible under normal or accident conditions. The use of less than equivalent full water reflection and the method of analysis to determine the equivalent water reflector thickness should be justified. If a more effective reflector than water is present (e.g., concrete) it should be considered in the analysis.

Safety margins for the individual units should be specified (e.g., safety factors for large units, dimensions for small units). Safe unit geometry and safe unit spacing will differ from plant to plant, process to process, and SNM content of materials in process. For this reason, the applicant should provide tables of the maximum safe parameters for individual units of the plant and the criteria for spacing between units in an array.

For the convenience of the applicant, criticality safety design methods acceptable to the NRC staff are provided in Appendix A to this guide.

15.4 Analytical Methods and Validation References

Describe and demonstrate the use of the validation of the analytical methods used and their applicability to the systems being analyzed.

15.5 Data Sources

The sources or references for the applicable data should be specified.

15.6 Fixed Poisons

In the event that borosilicate glass raschig rings are used as a primary or secondary means of criticality control, describe how they are used and maintained. (In this connection, guidance is provided in Regulatory Guide 3.1, "Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material.") Alternative poison material may be used if safety justification is provided. Justification includes the determination of the initial and continuing presence and effectiveness of the poison material.

15.7 Structural Integrity Policy and Review Requirements

Show that the structural integrity for single units and arrays is ensured by providing adequate margins of safety for all credible accident conditions and that the engineering design is reviewed by a qualified person to ensure an adequate margin of safety under all normal and abnormal conditions.

15.8 Special Controls

Any other special controls used to ensure nuclear safety such as zoning for fire protection should also be described.

Chapter 16 PROCESS DESCRIPTION AND SAFETY ANALYSES

16.1 Process Steps and Flowsheet

Describe in detail the process equipment and associated controls. Include in this description ancillary activities if pertinent to the main process, i.e., preparation of reactants, offgas handling, volume reduction of wastes, decontamination, and scrap recycling.

In support of the description, supply flowsheets showing the process, materials, and instrumentation. Provide identification of the process and effluent streams in sufficient detail to permit an independent review to ensure a safe operation. That should include activities, compositions, properties, sample points, and identification of primary control points. Justify the conclusions relevant to safety and environmental effects.

16.2 Safety Analysis of Each Step

Provide a safety analysis of each step of the process. The applicability of all methods of analysis specified in Part I should be demonstrated.

16.3 Safety Features of Each Step

Describe all safety-related features, systems, or special handling techniques included in the system for the safety of the operation under both normal and abnormal conditions. Include the limit(s) selected for a commitment of action. Provide a summary description of the principal design guidance, procedures, and special techniques used to preclude criticality in all steps of the process. Describe the location of criticality detectors. Provide a summary description of the principal chemical and fire hazards and the approaches used to preclude accidents.

Chapter 17 ACCIDENT ANALYSES

Summarize the types of accidents considered and their impact on the environment. Make appropriate reference to the Environmental Report.

APPENDIX A

SAFETY MARGINS AND INTERACTION CRITERIA

For the convenience of the applicant, criticality safety design methods acceptable to the NRC staff, including maximum safe parameters for individual units and criteria for spacing between units in an array, are provided in this appendix.

1. SAFETY MARGINS

The following are acceptable margins of safety for individual units: when double-batching is possible, mass limits should be held to no more than 0.45 of the minimum critical mass based on spherical geometry; when double-batching is not possible, the mass should be limited to no more than 0.75 of the critical mass. Mass limits should be based on experimental data or on calculations performed by a method that has been validated for the type of system being analyzed. Acceptable geometry margins of safety for large single units are 90 percent of the minimum critical cylinder diameter, 85 percent of the minimum critical slab thickness, and 75 percent of the minimum critical sphere volume. Maximum safe dimensions must be specified for small units.

Safe cylinder diameters, slab thicknesses, unit masses, and volumes may be tabulated in the application as a function of moderation, enrichment, reflection, etc. The specific values tabulated should meet the above criteria or may correspond to a unit k_{eff} that provides an adequate margin of safety under specified normal and credible abnormal conditions. The evaluated multiplication factor under normal and credible abnormal conditions must be equal to or less than an established maximum safe allowable multiplication factor (k_a), i.e.,

$$k_s \leq k_a$$

where

k_s = the evaluated multiplication factor, including any necessary allowance for statistical uncertainties.

The maximum allowable multiplication factor should be calculated from the expression:

$$k_a = k_c - \Delta k_u - \Delta k_m$$

where

k_c = the value of k_{eff} that results from the calculation of benchmark experiments using a particular calculational method. The value represents a combination of theoretical techniques and numerical data.

Δk_u = the uncertainty in the benchmark experiments, including random and systematic errors (bias) within the range of parameters encountered in the equipment design.

Δk_m = the value required to ensure an acceptable margin of subcriticality. In the absence of information that justifies a smaller margin of safety, a value of 0.05 should be assumed for Δk_m in equipment design.

2. INTERACTION CRITERIA

Desirable spacing criteria include:

a. The closest approach of one individually subcritical unit to another should be limited by mechanical means or by clearly delineated criticality zones.

b. The array analysis should allow for double-batching of a single position in the most limiting array position (or positions) credible.

c. The array analysis should account for interunit moderation unless it can be shown that moderation is not credible.

d. The array analysis should include a conservative allowance for spatial tolerance in unit positions.

e. Mixed array criteria should be used where applicable (e.g., solutions and solids).

The licensee should identify the criteria to be used in spacing. Acceptable criteria for the spacing of process equipment and stored units include the following:

a. Validated KENO calculations should yield a maximum k_{eff} of 0.95 at the 95 percent confidence level.

b. The maximum safe surface density should be limited to 25 percent of the critical surface density of a fully water-reflected uniform slab of the appropriate composition when each unit in the array has a maximum quantity of fuel that is no more than 30 percent of critical for a bare assembly, based on container geometry, fuel composition, and the degree of water moderation of interest.

c. The nuclear criticality safety criteria for arrays may be based on the application of the solid angle method. The method of analysis should be demonstrated applicable to the system being analyzed.

d. In the application of the density analog method, safety factors of 2 should be used for the maximum allowable number of units. Factors for reflection and moderation must also be applied.

APPENDIX B

SAMPLE LISTING OF TREND ANALYSIS TOPICS

1. Higher personnel exposures than expected.
2. Higher concentrations of airborne concentrations in plant areas than expected.
3. Radioactive contamination in areas and on equipment not normally contaminated.
4. Unauthorized entry into work areas.
5. Unapproved storage or use of nuclear materials.
6. Unauthorized disposal of nuclear materials.
7. Failure of required radiation measurement instrumentation to operate properly.
8. Failure of protective respiratory equipment to work properly.
9. Failure of effluent filters to meet specifications.
10. Significant lapse of failure of the double contingency criterion for nuclear criticality safety such as:
    a. Accidental double-batching;
    b. Unauthorized transfer of SNM from a safe to unsafe geometry;
    c. Accidental distortion of safe geometry equipment approaching an unsafe configuration (includes corrosion);
    d. Detection of unexpected accumulations of SNM;
    e. Failure of racks or shelving for SNM;
    f. Receipt of new material out of specifications (too much moderation in "dry powder," too high enrichment);
    g. Unexpected loss of effectiveness of poisons (dissolution, distortion);
    h. Unexpected moderation in moderation-controlled units and systems; or
    i. Installation and use of unauthorized equipment for SNM.

VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," specifies the information to be supplied in applications for licenses to possess and use special nuclear material in uranium fuel fabrication plants. However, Part 70 does not specify the format for presentation of the required information. The proposed action would provide format and content guidance in the preparation of applications for license renewal for uranium fuel fabrication plants.

1.2 Need for Proposed Action

At the present time, there is no published guidance that defines the format and the detailed information needed in the application for a license renewal. The NRC Office of Inspector and Auditor reviewed the license renewal process for fuel fabrication facilities in a January 1978 report to the Commissioners. It concluded that the staff should pursue the development of applicable guides, foremost of which is this standard format and content guide.

At present there are 14 licenses in effect that require renewal from time to time. The NRC licensing staff expects in the foreseeable future more renewal applications than first license applications. Hence, this guide for renewal of a license application was prepared first.

1.3 Value/Impact of Proposed Action

1.3.1 NRC Operation

The proposed action should identify the type of information needed and the desired presentation format to facilitate orderly NRC staff review of license renewal applications for uranium fuel fabrication plants. The staff review effort should be reduced because the license applications should be more closely in compliance with the intent of the regulations. Considerable time on the part of the Office of Inspection and Enforcement may be saved because the license conditions should be more complete and inspectable and should therefore require less time for the resolution of findings.

1.3.2 Other Government Agencies

Other government agencies are not involved in this proposed action; therefore there is no value/impact on other agencies.

1.3.3 Industry

The proposed action should expedite the licensing process, which should reduce licensing delays and costs. Since the standard format and content should specify all the regulatory licensing requirements, less time and effort should be required for the resolution of comments.

1.3.4 Public

The proposed action should improve public understanding by providing information regarding the NRC licensing process. There could be a cost reduction to the public as taxpayers and consumers because of the improved efficiency of the licensing process and the subsequent inspection process that NRC must perform at licensed fuel fabrication plants.

1.4 Decision on Proposed Action

Format and content guidance should be furnished for the preparation of applications for license renewal for uranium fuel fabrication plants.

2. TECHNICAL APPROACH

2.1 Technical Alternatives

a. Conduct licensing reviews on an individual case basis using existing or modified procedures.

b. Provide additional guidance in the form of a standard format and content guide for the preparation of license applications.

2.2 Discussion and Comparison of Technical Alternatives

The proposed action should result in license applications that contain more complete information and the data required for licensing. This should help to ensure thoroughness and improve the efficiency of the NRC staff review.

3. PROCEDURAL APPROACH

Several methods of making public the proposed guidance were considered and evaluated. As a result, a regulatory guide was selected as the best alternative for the proposed action because it was considered the most effective and efficient method of accomplishing the needed guidance.

4. STATUTORY CONSIDERATIONS

4.1 NRC Authority

NRC authority for issuance of this guide derives from the Atomic Energy Act of 1954, as amended, through those portions of the Commission's regulations in Title 10 of the Code of Federal Regulations cited in the introduction to the guide.

4.2 Need for NEPA Assessment

The proposed action is not a major action significantly affecting the quality of the human environment as defined by paragraph 51.5(a)(10) of 10 CFR Part 51 and does not require an environmental impact statement.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

The proposed regulatory guide has to be consonant with future standard formats of new license applications for uranium fuel fabrication plants (in contrast to renewals). It will serve as a basis for developing standard review plans for license renewal applications.

6. SUMMARY AND CONCLUSIONS

A regulatory guide should be prepared for the standard format and content of the health and safety section of license renewal applications for uranium fuel fabrication plants.

6-2/8.18/rev.1

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October 1982

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

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REGULATORY GUIDE 8.18

INFORMATION RELEVANT TO ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES AT MEDICAL INSTITUTIONS WILL BE AS LOW AS REASONABLY ACHIEVABLE

A. INTRODUCTION

Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states that licensees should make every reasonable effort to keep radiation exposures, as well as releases of radioactive material to unrestricted areas, as far below the limits specified in that part as reasonably achievable. Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable," sets forth the philosophy and general management policies and programs that licensees should follow to achieve this objective of maintaining radiation exposures to employees "as low as is reasonably achievable" (ALARA). Regulatory Guide 10.8, "Guide for the Preparation of Applications for Medical Programs," includes information on an acceptable management program for keeping exposures ALARA, as well as specific examples of radiation safety programs and practices acceptable to the NRC licensing staff. These examples supplement the general outline of principles and practices contained in this guide and in an associated report, NUREG-0267, "Principles and Practices for Keeping Occupational Radiation Exposures at Medical Institutions As Low As Reasonably Achievable" (Ref. 1).

This guide is directed specifically toward medical licensees and recommends methods acceptable to the NRC staff for maintaining occupational exposures ALARA in medical institutions. NUREG-0267 is a compendium of good practices and helpful information derived from the experience of the radiological and health physics professions and is not to be construed in any way as additional regulatory requirements of the Nuclear Regulatory Commission. In fact, many of the suggestions made in the report are based on accepted health protection practices not specifically addressed in NRC regulations. NUREG-0267 also provides a reference list that may be used for background information on radiation protection science and philosophy, radiation protection standards, and planning and design information useful for radiation protection programs in medical institutions. Sections of the report are keyed to the section numbers of this guide for the reader's convenience.

This guide is generally directed toward occupational health protection. However, in a medical institution, certain persons other than employees are exposed to radiation from NRC-licensed radioactive material. These persons include visitors as well as patients other than those being treated with radioactive material. Protection of these individuals is also addressed in this guide. The content of this guide is also applicable to veterinary medical institutions insofar as specific diagnostic or therapeutic procedures are performed. Similar protection practices are applicable for keeping employee and visitor exposures ALARA, whether the patients are animal or human.

Specific guidance regarding radioactive materials in effluents to unrestricted areas is beyond the scope of this guide. This topic is mentioned only in connection with actions that influence both occupational exposure and effluent control. Further details on this subject are given in Regulatory Guide 10.8. In addition, this guide and the associated report (Ref. 1) deal only with radioactive materials subject to licensing by the Nuclear Regulatory Commission. The regulations and recommendations of other agencies should be consulted in regard to controlling radiation exposures from x-ray machines, other radiation-emitting equipment, and materials not licensed by NRC.

B. DISCUSSION

The principle of maintaining occupational radiation exposures ALARA is an extension of an original recommendation of the National Committee on Radiation Protection (now the National Council on Radiation Protection and Measurements (NCRP)) in its 1949 report (published in 1954 as Report No. 17 (Ref. 2)). In this early report, the NCRP introduced the philosophy of assuming that any radiation exposure may carry some risk and recommended that

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*Lines indicate substantive changes from previous issue.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
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radiation exposure be kept at a level "as low as practicable" (currently referred to as "ALARA") below the recommended maximum permissible dose equivalent. Similar recommendations to keep exposures ALARA have been included in NCRP reports (Ref. 3), as well as in recommendations of the National Academy of Sciences–National Research Council (Ref. 4), the Federal Radiation Council (Ref. 5), and other independent scientific and professional organizations (Refs. 6-8). The basic radiation protection philosophy of these recommendations has been incorporated in regulations and guides of the Nuclear Regulatory Commission.

This guide and the associated report provide a supplement for medical institutions to the basic philosophy of Regulatory Guide 8.10, which lists for all specific licensees the types of management commitments and radiation protection programs that would help to achieve the objective of maintaining occupational exposures ALARA. This guide, Regulatory Guide 8.10, and Regulatory Guide 10.8 will be used as a basis for evaluating license applications and radiation safety programs of NRC-licensed medical institutions, unless the licensee proposes an alternative method of complying with specified portions of the Commission's regulations.

C. REGULATORY POSITION

A licensee's radiation safety program will be considered in compliance with the 10 CFR Part 20 ALARA requirement and in accord with the ALARA philosophy if the major principles and practices identified below are adopted and implemented as part of the institution's policies and programs.

1. MANAGEMENT PHILOSOPHY AND ORGANIZATION

The radiation protection responsibility of licensee management[1] at a medical institution is to maintain exposures ALARA for employees, visitors, students, and patients who do not receive radiation or radioactive materials as part of their hospital care. This responsibility should be carried out by means of:

a. Information and policy statements[2] to the medical and hospital staff;

b. Periodic management audit of operational efforts to maintain exposures ALARA;

c. Continuing management evaluation of radiation safety staffing, program, and budget requirements;

d. Management programs to ensure that all staff and employees who may be exposed to radiation receive appropriate briefings and training in radiation safety, including ALARA concepts;

e. Delegation of sufficient authority to the Radiation Safety Officer[3] (RSO) to enforce regulations and administrative policies regarding radiation safety; and

f. Administrative direction to ensure that any new hospital facilities or equipment that may affect radiation protection will be planned or designed in consultation with the RSO.

A model program for implementing this management philosophy is presented in Appendix O to Regulatory Guide 10.8.

2. RADIATION SAFETY OFFICE FUNCTIONS

The term "Radiation Safety Office" is used here only to indicate that some entity should be established to direct and coordinate administrative aspects of the radiation safety program. The extent of this program should be commensurate with potential radiation protection problems.

2.1 Staffing and Organizational Requirements

A sample outline of the various tasks of a typical Radiation Safety Office is presented in the appendix. The time and effort required for each of the listed tasks vary widely with the size of the medical institution and the nature and extent of radioactive material usage. Management (1) should review the staffing requirements for each of these tasks and provide the necessary personnel to establish and carry out radiation safety program requirements and (2) should evaluate them on an annual basis.

2.2 Radiation Safety Personnel Qualifications

Management should select radiation safety personnel appropriate to the radiation safety program after careful review of the nature of the program and the extent of effort and expertise required to carry out the tasks noted in the appendix.

2.3 Space and Equipment

The Radiation Safety Office should have adequate equipment and space in appropriate locations to carry out the following functions:

a. Maintain, repair, and perform electronic calibrations on radiation safety equipment.

b. Calibrate in radiation fields radiation safety and survey equipment (and check the calibrations of other hospital radiation sources if radiation safety and medical physics functions are combined).

c. Stock radiation safety supplies for labeling, surveying, decontamination, and personnel protection and monitoring.

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[1] "Management" is defined here as those persons authorized by the charter of the medical institution to make its policies and direct its activities.

[2] Policy statements should include a detailed set of radiation exposure investigational levels as presented in Regulatory Guide 10.8, Appendix O.

[3] The title "Radiation Safety Officer," used by many medical licensees, is used in this guide to designate the qualified individual who is responsible for carrying out the institution's radiation safety program and who is listed as the Radiation Safety Officer on the institution's "Application for Materials License–Medical," Form NRC-313M (see Exhibit A of Regulatory Guide 10.8).

d. Conduct radiometric measurement of smear tests from contamination surveys and source leak tests.

e. Store radioactive wastes and sources not in use.

f. Decontaminate personnel, clothing, and equipment.

g. Process orders for licensed radioactive materials and receive and distribute such materials.

h. Receive, process, and file regulations and licensing correspondence.

i. Prepare reports and records of surveys and personnel monitoring as required by 10 CFR Part 20.

j. Instruct and brief personnel as required by 10 CFR Part 19.

In addition, the tasks listed in the appendix should be examined for other activities that may require specific space allocations for Radiation Safety Offices in larger hospitals.

2.4 Tasks and Procedures

The RSO and the radiation safety staff are responsible for conducting surveillance programs and investigations to ensure that occupational exposures are ALARA. In addition, they should be vigilant in searching out new and better ways to reduce doses for jobs involving radiation exposure. A list of the types of tasks carried out by a Radiation Safety Office in order to provide good radiation safety surveillance and meet regulatory and license conditions is presented in the appendix.

For medical institutions in which a full- or part-time professional health physics staff is available, the planning of radiation safety procedures by this staff should be carried out in coordination with management to ensure optimum efficiency and exposures that are ALARA. This coordination should extend to the implementation of the ongoing radiation safety program by the professional health physicists under the general supervision of the RSO.

2.5 Administrative Authority

The Radiation Safety Office, supervised by the RSO, should have responsibility for carrying out the radiation safety program, including the tasks listed in the appendix. This responsibility should be formally delegated in writing by responsible management and should include authority for the RSO to communicate directly with the level of management that can take corrective action when needed to enforce rules and procedures pertaining to the institution's radiation safety program. Administrative authority to suspend certain activities temporarily should also be provided to the RSO when needed in emergencies to avoid immediate danger to life or health. However, the authority of the RSO to suspend activities should be exercised only when it will not interfere with life-saving medical procedures that warrant an overriding priority and that cannot await alleviation of the radiation safety problems.

2.6 Radiation Safety Committee

Part 35 requires that a radiation safety committee be appointed to supervise the institution's radiation safety program. Typical functions and responsibilities of the committee are given in Regulatory Guide 10.8. The RSO, who is required to be a member of the committee, may either serve as chairman or assist the chairman in preparing for and conducting meetings and maintaining committee records.

Meetings of the committee should be held at least quarterly. Every member of the committee should be invited to each meeting.

The purposes of the meetings should include:

a. Discussing any radiation safety problems requiring a general solution;

b. Determining whether current procedures are maintaining exposures ALARA;

c. Considering new proposals for the use of radioisotopes and evaluating the safety of those uses and the qualifications of the users; and

d. Auditing the radiation safety program to ensure that it meets all the goals presented in Sections C.2.1 through C.2.5 and all pertinent regulations.

All radiation safety committee meetings should be documented by a record of minutes approved by committee members and filed as part of the radiation safety record system within 60 days following each meeting.

3. FACILITY AND EQUIPMENT DESIGN

3.1 General Considerations

The design of facilities and equipment required for the medical uses of radioactive materials depends not only on hospital and medical care considerations, but also on the nature and quantity of radioactive materials involved and the relative potential for external and internal radiation exposure. Major aspects of planning and design that should be considered are discussed below.

3.1.1 Space Layout

Facility layout should be planned to maintain employee exposures ALARA while at the same time ensuring that exposure is not thereby increased to other persons in restricted or unrestricted areas. Considerations should include:

a. The need for access to radiation or radioactive materials areas by medical staff, employees, patients, visitors, and others, while at the same time providing optimum separation between workers' "sit down" areas of frequent occupancy and radiation sources or contamination;

b. Ventilation requirements, including whether there is a need to maintain lower pressures in rooms in which radioactive materials may possibly be spilled or volatilized;

c. Floor loading for heavily shielded sources;

d. Receipt and shipment of radioactive materials, including radiation surveys of the shipping containers;

e. Ingress and egress of some radiation therapy and nuclear medicine outpatients, including parking; and

f. The need to protect supplies of stored diagnostic films from radiation exposure.

3.1.2 Shielding

Permanent shielding may be needed in some cases for walls, floors, and ceilings to provide protection against radiation from radioactive materials currently housed in the institution, as well as radioactive materials that might be introduced into the area by future medical care requirements. Section 3.2 contains a discussion of permanent shielding for radiation therapy facilities. Teletherapy installations always require permanent shielding. Occupancy and use factors should be taken into account as recommended in NCRP handbooks, but such factors should be chosen with the principle of ALARA in mind. The NRC licensing staff should also be consulted during the planning and design stage to obtain licensing guidance on acceptable use and occupancy factors in shielding design.

3.1.3 Caution Signs and Interlocks

Access to certain areas should be controlled or restricted by the use of caution signs, signals, and interlocks as required by § 20.203 of 10 CFR Part 20.

3.1.4 Ventilation

To the extent possible, the licensee should:

a. Provide any necessary local exhaust ventilation (such as chemical hoods) or general ventilation as recommended by professional health physicists for areas where breathable concentrations of radioactive material may be present.

b. Design exhaust systems to avoid transporting contaminated air through long ductwork passing through many other hospital areas on its way to the stack on the roof.

c. Locate exhaust vents so as to provide meteorological diffusion and dilution adequate to meet § 20.106 of 10 CFR Part 20 requirements for effluents to unrestricted areas and ALARA exposure considerations for the public, as well as to avoid recirculating contaminated exhaust air into the building.

d. Where appropriate, include specific types of filters or air cleaners for the exhaust air.

e. Rooms in which radioactive gases or aerosols may be released should be maintained at negative pressure with respect to adjacent rooms by appropriate exhaust ventilation as in a.

3.1.5 Fire Control

The need for personnel exit and for closing the facility to prevent the spread of radioactive materials should be considered for areas where laboratory procedures could result in dispersal of radioactive materials in the event of a fire. Provision should be made for local showers and fire extinguishers, where necessary. For the vast majority of medical institutions, emergency procedures and training should include immediate fire control as a priority item.

3.1.6 Special Laboratory Design Features

Consideration should be given to providing laboratory surfaces that may be easily cleaned and decontaminated daily to maintain minimal contamination levels and radiation exposures, as well as minimal interference with medical and clinical procedures. Laboratory needs may also include:

a. Provision for appropriate placement of radiation- and contamination-monitoring instruments;

b. Designated sinks for rinsing and disposing of minor quantities of radioactive wastes (within 10 CFR Part 20 limits);

c. Special plumbing and waste storage provisions; and

d. Adequate separation between areas occupied by personnel and radiation sources or contamination.

In general, there is no need in hospitals for any procedures that would use quantities of radioactive material sufficiently radiotoxic that potential air concentrations may reach levels approaching the concentration values given in 10 CFR Part 20. Ventilation and contamination control should be designed to maintain air concentrations and contamination levels as low as reasonably achievable. Guidance for the use of Xe-133 in nuclear medicine is available from the Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, or in Regulatory Guide 10.8.

3.1.7 Storage, Source Control, and Inventory

In institutions ordering a number and variety of sources of radioactive material, it is often easier, less costly, and more secure to provide a centralized storage room for radioactive materials not in use or used only occasionally. Such a facility is also helpful in keeping exposures ALARA, since it may result in a decrease in the amount of radioactive material stored in laboratories occupied by personnel.

3.1.8 Shipping and Receiving

Medical institutions should:

a. Plan specific radioactive material storage areas for day, night, and weekend deliveries so that deliveries of radioactive materials may be received at any time and placed in a secure locked location where they will not cause unnecessary exposure to personnel while awaiting survey by the Radiation Safety Office or the user. A written procedure for receipt, survey, and storage of deliveries should be provided to anyone responsible for the receipt or delivery of radioactive material.

b. When packages may expose couriers to measurable radiation, make available a cart or carrier that will maintain an adequate distance between the person transporting the material and the package to keep exposures ALARA.

c. Provide space in the receiving area for an initial survey and smear test of each package unless other means are used to avoid transporting a contaminated package through unrestricted areas of the hospital.

d. Locate shipping and receiving areas and the access to them away from areas where radioactive materials are used so as to (1) minimize the time required for transporting radioactive material to areas where it is to be used and (2) avoid the need to transport radioactive materials through crowded areas or areas occupied by personnel, patients, or visitors.

3.1.9 Equipment Considerations

General features applicable for equipment that will be used for handling or containing radioactive materials are as follows:

a. Surfaces should be easy to clean and decontaminate in case unsealed radioactive material is released.

b. Equipment should be designed to optimize the ease of carrying out procedures where personnel are exposed to radiation, thereby minimizing working times, and to maximize distances of personnel from the radioactive materials with which they are working to an extent consistent with the purposes of the procedure.

c. Equipment should operate in such a fashion that it does not damage radiation sources and release radioactive materials if it fails.

d. Adequate shielding should be provided as part of the equipment, where feasible, to keep exposures ALARA.

e. Appropriate caution signs, symbols, signals, and alarms should be provided as part of the equipment to meet the requirements of § 20.203 of 10 CFR Part 20 and recommended standards of the medical physics profession.

3.2 Radiation Therapy Equipment and Facilities

Specific NRC licensing guides are provided for licensed radiation therapy programs, and the NRC licensing staff reviews the safety aspects of facilities and equipment before issuing a license. In designing shielding for teletherapy treatment rooms, the medical institution should consult NCRP Handbook 34 or 49 (Ref. 9) for recommended design details; specifications; methods of shielding against direct, scattered, and leakage radiation; and general principles of radiation safety design.

In addition, the institution should:

a. Protect each teletherapy treatment room from inadvertent entry by the following means:

(1) Provide a door interlock that allows a "Beam On" condition only when the door is closed, and turns the beam off if the door is opened.

(2) Provide independent backup caution lights on the console, above the door, and inside the treatment room to indicate the "Beam On" condition to radiotherapy technologists and other staff members. Independent audible signals also provide added safety in the event the caution lights fail.

(3) Establish a procedure for checking whether everyone except the patient is out of the treatment room before the door is closed and the beam is turned on.

(4) Install independent gamma ray sensing caution lights or signals near the entry inside teletherapy treatment rooms to provide a warning to the therapy technologist or others entering the room in case the door interlock system fails when the beam is in the "on" condition.

(5) Provide a "scram" button for emergency shutdown of the source from inside the teletherapy room and provide audio communication with the outside control panel.

b. Consider leakage through the teletherapy head with the source in the "on" position when designing shielding. Data provided by the manufacturer of the teletherapy machine and NCRP recommendations should be used for this purpose.

c. Design areas adjacent to the treatment room that will be occupied by personnel, patients, or visitors who are not associated with the radiation therapy department so as to maintain exposures ALARA. Reduction of occupational exposures to radiation therapy personnel should be achieved by design provisions, procedures, or beam orientations that are directed toward unoccupied or low-occupancy areas. In no case should it be necessary to design for instantaneous rates greater than 10 mrad/week in restricted or unrestricted areas adjacent to teletherapy treatment rooms.

3.3 Nuclear Medicine Facilities

To ensure that exposures are ALARA, layout and design for new nuclear medicine facilities and equipment should:

a. Allow sufficient space for personnel operating nuclear medicine equipment to be at least one meter and preferably two meters from any patient undergoing imaging whenever the condition of the patient and other conditions permit, or provide adequate portable shields.

b. Allow adequate space for stretcher patients awaiting scans as well as for outpatients. Dosed patients awaiting scans may cause radiation levels on the order of 10 mR/h or more near the edge of the stretcher. They may need to be segregated from the general waiting area to reduce radiation exposure to receptionists and persons passing through the area, such as orderlies and aides.

c. Locate physicians' offices and other occupied areas within easy access to needed radiopharmaceuticals, but allow enough distance (several meters is usually sufficient) to minimize exposures from stored radiopharmaceuticals and radioactive wastes.

d. Provide adequate shielding for stored radiopharmaceuticals and adequate body shielding for employees preparing dosage for patients.

e. Supply an adequate number of syringe shields and vial shields (as well as appropriate tongs or forceps) near the place of dosage preparation.

f. Provide adequate exhaust ventilation (Ref. 10) in the laboratory near or in the radiopharmaceutical storage and dose preparation areas to protect against airborne radioactive or toxic materials that might result from accidental release or spill of radiopharmaceuticals.

g. Include a special shielded waste receptacle for used syringes and other radioactive wastes in the nuclear medicine laboratory near the dosage preparation area.

h. Locate a permanently fixed radiation counter or rate meter near the entrance to the nuclear medicine preparation laboratory for employees to check regularly for hand or clothing contamination when leaving the department. A portable survey meter available at a convenient location will also help keep exposures ALARA.

i. Provide individual labeled lockers and change areas for segregating laboratory coats that may be contaminated from other clothing when operations are such that contamination levels on persons or clothing may exceed action levels of Regulatory Guide 8.23, "Radiation Safety Surveys at Medical Institutions."

j. Provide finger badges or dosimeters as well as body dosimeters for monitoring occupational exposure of personnel involved in dose preparation and injection and handling of patients.

3.4 In Vitro Clinical and Research Laboratories

Many of the design considerations for in vitro clinical and research laboratories are similar to those already given for other facilities. Special considerations include:

a. Easily discarded bench paper, absorbent on the top surface only, for catching and easily disposing of small amounts of contamination that may drip or be removed from laboratory apparatus and glassware.

b. Suitable easily cleaned drip trays for carrying out manipulations of radioactive materials where spillage may occur.

c. Protective clothing, including rubber or plastic disposable gloves, for persons working with radioactive materials. (Disposable gloves should be changed frequently.) Equipment should be provided for monitoring clothing before laundering. Radioactive laundry and radioactive wastes should be turned over to the Radiation Safety Office for further disposition when surveys indicate contamination levels may exceed 10^{-5} $\mu Ci/cm^2$

Additional information on carrying out in vivo experiments with animals is given in Reference 11 and NUREG-0267.

4. SAFE WORK PRACTICES AND PROCEDURES

4.1 General Principles

The safe work practices and procedures contained in this section for handling radioactive materials in medical institutions are recommended as a minimum. Additional information is contained in NUREG-0267, Regulatory Guide 8.23, and Regulatory Guide 10.8.

4.1.1 Periodic Inventory and Control of All Radiation Sources

Many of the more serious occupational exposures, as well as patient exposures, have resulted from misplaced or lost radioactive material, which then may inadvertently expose unsuspecting persons or may be subject to improper usage by unauthorized persons. The following procedures should be taken to guard against these problems:

a. Periodic inventories should be made of all radioactive sources, and a continuous record of the locations of all sources and their usage should be maintained. The inventory should be combined with an inspection to ensure proper labeling (see § 20.203 of 10 CFR Part 20). Paragraph 35.14 (b)(5)(v) of 10 CFR Part 35 requires inventories of sealed sources in Group VI and calibration sources to be conducted at least quarterly. Inventory procedures should also provide for the RSO to be alerted if all sources are not returned within a specified time in order to avoid sending patients home with brachytherapy sources still in place (see Reference 12).

b. Sources should be secured within locked rooms or storage areas when authorized users or their responsible employees are not present (see Section C.3.1.7 of this guide). Special shielded vaults or containers should be provided in the storage area for sealed sources.

c. Authorized persons should be required to sign for the removal and return of each source. The source log should be checked regularly by the Radiation Safety Office staff.

4.1.2 Shielding

All radioactive material not in use should be shielded so that exposure rates in any area that may be occupied by personnel will be well below (ALARA) the levels for unrestricted areas given in 10 CFR Part 20. Whenever radioactive materials are in use, the material should be unshielded only in the direction necessary for its use and to the extent that accessibility to the source is necessary.

4.1.3 Control of Contamination

Radioactive materials in unsealed form or undergoing chemical or physical processing should be handled only in properly designed facilities (as described in Section C.3.3 above) and with proper procedures to avoid transferring radioactive material to the air or to surfaces if inhalation or ingestion of the material by personnel is possible. Heat sterilization should be avoided if it might cause rupture of the source. If necessary to ensure that exposures are ALARA, preliminary tests of procedures should be carried out with nonradioactive simulated materials or colored liquids to check provisions for containment, handling, and ventilation. The Radiation Safety Office staff may make preliminary estimates of job exposure commitments using tracer levels of radioactive material.

Trays and absorbent materials should be used as a backup to catch and limit the spread of radioactive contamination whenever there is a possibility that planned procedures will fail to contain the radioactive material.

Protective clothing appropriate to the type and quantity of radioactive material being processed should be worn whenever escape of radioactive contamination is considered possible.

4.1.4 Proper Work Habits

In general, all personnel handling radioactive materials should be trained to use appropriate shielding materials, maintain as much distance as possible from radiation sources, and limit the time of exposure to radiation sources to the time necessary to carry out the required task or clinical procedure.

The following good work habits are particularly important in ensuring that exposures are maintained ALARA:

a. Except for very-low-level sources such as flood sources or other sources designed for manual use in checking instrumentation, sealed or unsealed sources should not be touched or held with the fingers, but only with tongs or tweezers appropriate to the operation.

b. Finger dosimeters[4] as well as body dosimeters should be worn by personnel who are handling or manipulating unsealed or unshielded sources with tongs or forceps or who are holding partially shielded containers of radioactive material with their hands. However, these dosimeters are not needed for personnel handling only the types of sources used for tracer level in vitro studies or if dose rates are less than 5 mrem per hour at 1 cm.

c. Special attention should be given to instructing all nursing staff and others coming in contact with patients who may be excreting radioactive material that they also may need to follow precautions to avoid contaminating themselves and others.

d. When working with unencapsulated radioactive materials, personnel should wear rubber or plastic gloves and other special clothing.

e. Care should be taken to avoid needless contamination of objects such as light switches, taps, or door knobs.

f. Radioactive solutions should never be pipetted by mouth.

g. Eating, smoking, drinking, and application of cosmetics should be prohibited in laboratories where radioactive materials are handled.

h. Special precautions should be taken to avoid the possibility of small amounts of radioactive material entering into cuts.

i. The use of containers or glassware with sharp edges should be avoided. Care should be taken to avoid bites or scratches in working with animals to which radioactive materials have been administered.

j. Food and drink should not be stored in the same place (e.g., refrigerator) with radioactive materials.

k. Radioactive materials should be secured (e.g., placed in a locked room) when personnel are not present.

l. Surveillance of individual operations such as "milking" generators should be provided to ensure that workloads are distributed so that individual employee doses are kept ALARA.

4.1.5 Radiation or Radioactivity Monitoring

The independent radiation surveys, inspections, inventories, and smear tests to be carried out by the Radiation Safety Office staff were discussed in Section C.2. In addition, each user of radioactive materials should survey radiation and radioactivity levels within his or her own operations daily to help maintain exposures ALARA. A simple logbook of readings or general levels of radiation or contamination may be helpful if maintained by the user to indicate any changes in radiation or radioactivity levels that show a need for changes in procedures or equipment to meet ALARA radiation exposure objectives. Regulatory Guide 8.23 and Regulatory Guide 10.8 give further guidance on radiation surveys in medical institutions (and nuclear pharmacies).

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[4] With some finger dosimeters, labels may wash off or the badge may rip protective gloves. In these cases, wrist badges may be preferable. In any case, the user should be aware of the fact that neither of these dosimeters will measure very high finger contact doses, and handling unshielded syringes or bottles with the fingers should be absolutely avoided.

In hospital situations in which the higher exposure rates may occur (e.g., in teletherapy rooms where, in an accident, the limits of 10 CFR Part 20 could be approached before an indication is provided by routine personnel-monitoring devices), "self-reading" devices that may be read by the wearer at least daily, as well as warning devices worn on the body, may be helpful in maintaining exposures ALARA.

4.1.6 Training

Employees should be made aware of the ALARA provisions of § 20.1 of 10 CFR Part 20 and the guidance of Regulatory Guide 8.10. Employees should be instructed in the philosophy and recommendations of Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure," whenever there is a possibility that pregnant women may be exposed to radiation.

Each employee should be acquainted with the institution's own procedures for handling radioactive sources and radioactive materials and with NRC licenses and their radiation safety provisions (including license conditions incorporated from license applications and correspondence). Copies of these procedures, licenses, and related correspondence should be made available for review by employees as part of their orientation to radiation safety requirements. Professional education and development to ensure that staff members are up to date on radiation safety methods should also be supported.

Regulatory Guide 10.8 should be consulted for a list of topics important in training radiation workers.

4.2 Radiation Therapy

This guide provides recommendations for maintaining exposures ALARA in three subdivisions of radiation therapy:

a. Teletherapy–the treatment of patients with high-energy beams from shielded irradiators containing sources of high gamma ray emission rates.

b. Brachytherapy–the treatment of patients by insertion of sealed sources such as needles or tubes for interstitial or intracavitary irradiation or by surface application.

c. Radiopharmaceutical therapy–the injection or oral administration of solutions or colloids of radioactive pharmaceuticals that tend to concentrate in and irradiate the organs in which they are dispersed or absorbed.

4.2.1 Teletherapy

Radiation protection measures in teletherapy should rely primarily on the adequacy of facilities and equipment since very intense radiation levels are generated (see Section C.3.2). Nevertheless, some basic routine operating principles for maintaining occupational exposures ALARA should be followed:

a. With the aid of the maintenance and operating manuals provided by the manufacturer of the teletherapy unit, procedures should be established for routine maintenance and checkout of safety-related features of the teletherapy unit.

b. A daily morning checkout procedure should be established and posted for the therapy technologist to carry out simple operational checks of indicator lights, caution lights and signs, key and door interlocks, gamma radiation level indicators, timer operation, and interlock function.

c. A general safety check, including a spot or point radiation output check and check on beam alignment and confining devices, should be made and recorded at least monthly. All records of the monthly output and safety check, as well as the morning checkouts, should be signed and dated by the persons carrying out the tests.

d. During patient treatment or operation of the teletherapy unit for calibration or maintenance procedures, care should be taken to follow written instructions and use installed safety devices to ensure that no personnel except the patient to be exposed are in the teletherapy treatment room during the "Beam On" condition. These procedures are also important when personnel carry out test procedures with phantoms on the treatment table.

e. During "Beam On" operation, the operator at the console should remain in a position of lowest radiation intensity consistent with vigilance of the console and patient during treatment, as advised by the Radiation Safety Office staff using the postinstallation radiation survey. In a well-designed facility, the shielding provides a very high degree of protection at the location of the console. However, all persons not required to remain near the console should remain or work in areas of lower radiation intensity while the teletherapy unit is in operation. During "Beam Off" conditions, treatment setup should be accomplished with minimum occupancy of the room and minimum time spent near the source to keep exposures from leakage radiation ALARA.

f. Emergency procedures established as required by NRC regulations or license conditions should be tested by regular familiarization sessions or by staging mock emergencies for the training of personnel.

4.2.2 Brachytherapy

Detailed recommendations for reducing radiation exposures in brachytherapy are given in NCRP Report Number 40 (Ref. 12), and additional recommendations pertinent to brachytherapy, as well as radiopharmaceutical therapy, are contained in NCRP Report Number 37 (Ref. 13). Some of the most important practices for maintaining exposures ALARA are:

a. Modern afterloading devices should be used wherever medically acceptable. Remote afterloaders are particularly effective in keeping exposures ALARA.

b. Jigs or remote afterloaders should be prepared and tested for ease in loading sources into afterloading devices in the patient's room.

c. When manual afterloading is used, jigs for loading the afterloaders should be set up behind shields with lead glass viewing windows, and auxiliary lead brick shielding should be provided to shield the arms of the personnel loading the afterloaders for as much of the duration of the procedure as possible.

d. When the radiation sources of afterloading sleeves or ovoids are loaded, they should be placed in adequately shielded carts or transport devices for liquid sterilization or transport to the patient's room when the physician is ready to insert the afterloaders. These carts should be properly tagged and should at all times be under the supervision of the radiation physicist, the radiation safety staff, or a member of the radiotherapy staff.

e. Similar protection should be provided for use in threading radioactive needles for implant therapy.

f. While manipulating sources, loading the afterloaders, and threading needles, personnel should be provided with tongs and surgical clamps to maintain the distance of the fingers about 30 centimeters or more from these sources.

g. Finger dosimeters as well as body dosimeters should be worn by personnel when they are loading or preparing sources for insertion. Also, the Radiation Safety Office staff should periodically survey the loading procedures and provide job-time/exposure information to help employees maintain exposures ALARA. Use of a gamma alarm monitor in the storage or loading area will indicate when radiation sources are outside their shields and help avoid inadvertent exposure due to lost or misplaced sources.

h. A continuing list and count of removals and returns of individual sources from the storage containers should be maintained to help ensure against inadvertent loss of sources and exposure of personnel.

i. Sources maintained in fixed position for a constancy check on the operation of any intracavitary ion chambers should be maintained within shielded wells in constant geometry so they can be used for a rapid and safe check of ion chamber operation before the treatment of each patient.

j. Job-time/exposure studies should be carried out by the radiation protection staff on typical surgical implants and typical insertions of radioactive sources–either in the operating room or by afterloading in the patient's room. These time/exposure studies should be recorded and reported to the personnel involved to maintain an awareness of radiation exposures resulting from these procedures.

k. Transport of a patient containing radioactive material to areas outside the operating room and to his room should be directly supervised by the Radiation Safety Office staff or the radiation therapy staff. Also, transport of afterloading sources and supplies for insertion of applicators, lead bedside shields for the nurses, and any other supplies and equipment required for expediting an efficient afterloading procedure should be checked and supervised by the Radiation Safety Office staff or the radiation therapy staff. Radiation surveys should also be carried out on a sample basis and recorded to maintain an awareness of the exposures resulting from these procedures.

l. Nursing personnel should be provided with personnel dosimeters (when required by 10 CFR Part 20) and should be trained in their use.

m. Patients should be surveyed by the radiation safety staff after removal of brachytherapy sources and before discharge as a final step to check against incomplete removal of these sources from the patient, leakage of contamination from sources, or inadvertent loss of sources. Also, all linens and waste should remain in the room until checked by a survey meter or until all sources are accounted for.

4.2.3 Radiopharmaceutical Therapy (Nuclear Medicine Therapy with Unsealed Radioactive Materials)

Where feasible and in the best interests of the patient, administration of millicurie quantities of the types of radioactive drugs used for therapy of specific diseases should be carried out in a specific area or room separate from other nuclear medicine or radiotherapy operations. However, this special area or room should be in the general vicinity of the laboratory where the radiopharmaceuticals are stored to eliminate the need for transporting these materials over long distances or through other areas of the institution. When these materials must be transported to a patient's room for administration, good radiation safety practice and efficient medical procedure often dictate that the radiation safety staff should monitor and assist in the preparation of the materials and supplies, the transport of the materials to the patient's room, and the administration of the radioactive drugs as directed by the physician in charge. Precalibrated contained sources (e.g., capsules) should be used whenever possible. When therapy is carried out with potentially volatile radioiodine compounds, Regulatory Guide 8.20, "Applications of Bioassay for I-125 and I-131," should be consulted to determine whether employees who have participated in the radioiodine administration should be sampled for bioassay.

After treatment, all articles should be surveyed for possible contamination before they are released from the room. Contaminated articles must be released to the Radiation Safety Officer for decay or disposal. Also, the patient should be surveyed before release and should be instructed on ways to minimize contamination of the environment and exposure of other members of the public.

In supervising the administration of radiopharmaceuticals to patients, the physician in charge and the radiation safety staff may use many of the principles given for brachytherapy in Section C.4.2.2 above, as well as principles and practices presented in NCRP Report 37 (Ref. 13). The use of these procedures should help ensure that exposures to hospital staff and private duty nurses are ALARA not only during the administration of the dosage to the patient, but also during any hospital care of the patient, during and after discharge of the patient, and in the event of any later surgery, autopsy, or burial of the patient. Additional guidance is available from the Material Licensing Branch, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, and in Appendix K to Regulatory Guide 10.8.

4.3 Diagnostic Nuclear Medicine

Many of the principles of radiation protection practice in diagnostic nuclear medicine were discussed in previous sections on recommendations for nuclear medicine facilities and equipment (Section C.3.3) and general principles of safe work practices in handling radioactive materials (Section C.4.1). Additional recommendations are:

a. Use syringe shields for administering all injections of radioactive material; only compromise this procedure on rare occasions when absolutely necessary. Also, use gloves to protect against possible large doses from hand contamination.

b. Place radionuclide generators as far as possible from areas occupied by workers in other nuclear medicine operations, with adequate ventilation and additional shielding as necessary to reduce external as well as internal exposure to personnel during elution.

c. Use samples in shielded bottles for checking the assay of eluates in the nuclear medicine dose calibrator or other suitable assay system. Calibration procedures with a smaller quantity of radioactive material may sometimes reduce exposures ALARA. (See Regulatory Guide 10.8 for procedures.)

d. Shield chamber calibrators, where possible, to maintain employee exposures ALARA while nuclear medicine doses are being calibrated. Recalibrate refitted chambers as necessary.

e. Use fume hoods (Ref. 10) and good contamination control principles when preparing dosages of radiopharmaceuticals that have potential volatility or a potential for release from rubber septum syringes.

f. Keep shielded radioactive waste cans for used syringes and other radioactive wastes at the greatest distance from those areas in the laboratory most frequently occupied by personnel consistent with ease of disposal.

g. Use protective lead screens to protect employees and other patients during procedures using Tc-99m or other low-energy gamma emitters (for example, when there is a room full of patients awaiting brain scans) if the screens do not interfere with the diagnostic tests. Portable screens of Pb only 2 mm thick will reduce Tc-99m gamma-ray exposure rates to less than 0.5 percent of those without the screens.

h. In lung perfusion or ventilation studies with xenon-133, use additional lead shielding 1.6 mm thick (or appropriate thicknesses for other radioactive gases or aerosols) around the absorber canister, oxygen bag, and waste receptacle to reduce occupational exposures when frequent procedures are carried out. Also use proper equipment to prevent leakage or contamination from the radioactive material being used. Installation of a ^{133}Xe monitor in the room where ventilation studies are performed will warn of any leakage of ^{133}Xe.

i. In addition to regular nursing staff who receive personnel monitoring, private duty nurses and others who may come into close contact with patients who have been administered radiopharmaceuticals for diagnostic or therapeutic purposes should be carefully monitored for exposure and contamination and should receive appropriate instructions and briefings on radiation protection procedures.

4.4 Low-Level Clinical or Medical Research Laboratory Activities

Laboratories in medical institutions that use tracer amounts of the less radiotoxic nuclides may keep exposures ALARA by using the recommendations given in Section C.4.1. Many of the radionuclides used for in vitro clinical tests such as radioimmunoassay and other low-level in vitro or animal studies involve pure beta emitters or weak gamma emitters with only microcurie or submicrocurie quantities handled and processed by individual personnel at any one time. External and internal radiation exposures to personnel in such laboratories should ordinarily be maintained well below 10 percent of the permissible occupational exposure limits of 10 CFR Part 20 through careful initial planning of laboratory facilities, equipment, and procedures by the laboratory supervisor in conjunction with qualified health physics personnel.

5. MANAGEMENT AUDIT AND INSPECTION OF THE RADIATION SAFETY PROGRAM

Ultimate responsibility for the establishment and continuation of an adequate radiation safety program in a medical institution has been placed with the governing body of the hospital. The administrator reporting to this governing body should be sufficiently informed at all times to be sure that all regulations are faithfully adhered to and that the use and safe handling of radioisotopes are properly carried out to maintain exposures ALARA.

The hospital administration should carry out an annual audit of the radiation safety program in cooperation with members of the radiation safety committee and the Radiation Safety Office. The results of this audit may then be discussed at an annual radiation safety committee meeting to ensure that all users and responsible staff are aware of current policies and procedures and methods for their improvement. NUREG-0267 contains an example of a checklist of items that may be inspected by the administration during this annual audit. A report containing the results of the audit should be maintained by the Radiation Safety Office for possible use in expediting any inspections by regulatory or accrediting agencies, as well as for reference in further auditing and improving the ALARA program.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide. This guide reflects practices currently acceptable to the NRC staff. Except in those cases in which the applicant or licensee proposes alternative practices or methods for complying with specified portions of the Commission's regulations, the practices or methods described herein together with those in other applicable regulatory guides are being and will continue to be used as a basis for the evaluation of applications for specific materials licenses for medical institutions.

APPENDIX

RADIATION SAFETY TASKS INVOLVED IN KEEPING OCCUPATIONAL EXPOSURES ALARA

1. Surveys of the following radioactivity areas:

   a. Nuclear medicine
   b. Radiation therapy
   c. Oncology
   d. Pathology
   e. Cardiology
   f. Pediatrics
   g. Radioactive waste disposal and storage
   h. Other research and clinical laboratories using radioactive materials

2. Surveys of diagnostic and therapeutic machines and generators, including:

   a. Teletherapy sources and machines
   b. Computerized axial tomography scanners
   c. Interlock and safety checks
   d. Calibrations
   e. Fluoroscopes
   f. Radiographic x-ray

3. Personnel monitoring:

   a. Review of personnel exposure data and reports
   b. Preparation of reports required by regulations
   c. Filing, collection, and mailing of personnel monitoring devices (including late and lost)
   d. Special investigations of exposure and notifications to regulatory agencies where appropriate
   e. Calibration of personnel monitoring dosimeters, including commercially supplied film badge service

4. Radiation safety instrument calibration and maintenance:

   a. Calibration
   b. Battery replacement and adjustment
   c. Pocket chamber and TLD calibration
   d. Minor repair (electronic)
   e. Instrument selection and distribution
   f. Check-source calibration

5. Decontamination and waste disposal:

   a. Collection and packaging
   b. Surveying
   c. Recording
   d. Shipping arrangements
   e. Placarding
   f. Decontamination of surgical instruments, rooms, and laboratories

6. Leak-testing radioactive sources using the following techniques:

   a. Wiping
   b. Counting
   c. Calculations
   d. Recording
   e. Counter calibration

7. Evaluation of internal exposure by means of:

   a. Collection of samples, including air samples where applicable
   b. Radiochemical or scintillation bioassay analysis
   c. Counter calibration
   d. In vivo counting
   e. Computer analysis of results

8. Special surveys of patients and rooms for implant, intracavitary, or unsealed radiopharmaceutical therapy, including:

   a. Room preparation and protective covering
   b. Labeling (bed, chart, door)
   c. Nursing staff and housekeeping staff briefings
   d. Background surveys
   e. Source insertion and afterloading surveys
   f. Surveys of patients in operating room and recovery room
   g. Placing of lead barriers
   h. Recovery of sources and wastes
   i. Survey of room cleanup and decontamination
   j. Instructions to patient and to family of patient, as appropriate
   k. Measurement of radiation from cadavers, briefings to pathology staff and funeral directors, where appropriate

9. Administration and consultation, including:

   a. Approval of facilities, equipment, and procedures used in areas where radioactive materials are handled
   b. Preparation of license applications and amendments
   c. Preparation of hazard evaluation reports for licensing
   d. Programming of routine required surveys
   e. Supervision of routine radiation safety operations
   f. Revisions to radiation safety manual
   g. Periodic radiation safety instruction for hospital staff and administration
   h. Training of residents and medical staff
   i. Conferences with physicians and other safety staff

j. Coordination of Radiation Safety Committee meetings and minutes
k. Inspections and discussions with government regulatory agency representatives
l. Professional meetings
m. Selection and ordering of equipment and supplies
n. Planning and budgeting
o. Facility and shield design and meetings with architects
p. Record maintenance and related computer programming
q. Planning prompt effective response to incidents and emergencies involving radiation
r. Providing instruction or direction for outside persons (for example, firemen) who would respond to an emergency situation involving or potentially involving radiation
s. Preparation of Radiation Safety Office reports to hospital administration.

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REGULATORY GUIDE 3.8

PREPARATION OF ENVIRONMENTAL REPORTS FOR URANIUM MILLS

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Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

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INTRODUCTION

1. National Environmental Goals

Prior to the issuance of a license authorizing uranium milling activities, the Nuclear Regulatory Commission (NRC) is required to assess the potential environmental effects of the proposed activities in order to ensure that issuance of the license will be consistent with the national environmental goals. In order to obtain information essential for this assessment, the Commission requires each applicant for a license to submit a report on the potential environmental impact of the proposed uranium mill and related activities.

The national environmental goals are expressed by the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190, 83 Stat. 852), as follows:

> "...it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may--
>
> "(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
>
> "(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;
>
> "(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
>
> "(4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;
>
> "(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and
>
> "(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources."

In addition to NEPA, the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, numerous other pieces of legislation and implementing regulations, both Federal and State, may affect the siting and operation of uranium mills. Some of these laws, such as the Endangered Species Act of 1973, require the NRC to determine acceptability of the mill site and operation. Compliance with other laws such as the Federal Water Pollution Control Act must be merely reported to the NRC.

No attempt is made in this guide to discuss any of these requirements in detail. The applicant should make an independent determination of those statutes and regulations that may affect the proposed mill. Early consultation with the NRC staff is encouraged to determine the applicability of environmental requirements in specific instances.

2. Applicant's Environmental Reports

10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," § 51.40, "Environmental Reports," requires that each applicant for a license authorizing uranium milling submit 15 copies of a separate document, "The Applicant's Environmental Report," with the license application. The applicant must retain an additional 110 copies of the environmental report for distribution to Federal, State, and local officials in accordance with written instructions issued by the NRC's Director of the Office of Nuclear Material Safety and Safeguards. The applicant's environmental reports are important documents of public record. Therefore, the applicant is urged to give full attention to their accuracy and completeness.

The environmental report must discuss the following environmental considerations:

a. The environmental impact of the proposed action,

b. Any adverse environmental effects that cannot be avoided should the proposal be implemented,

c. Alternatives to the proposed action,

d. The relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity, and

e. Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

The discussion of alternatives to the proposed action in the environmental report must be sufficiently complete to aid the Commission in developing and exploring, pursuant to Section 102(2)(D) of the National Environmental Policy Act, "...appropriate alternatives...in any proposal which involves unresolved conflicts concerning alternative uses of available resources."

Under § 51.20, "Applicant's Environmental Report -- Construction Permit Stage," the environmental report must also include a benefit-cost analysis that considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects, as well as the environmental, economic, technical, and other benefits of the facility. The benefit-cost analysis must, to the fullest extent practicable, quantify the various factors considered. To the extent that such factors cannot be quantified, they must be discussed in qualitative terms. The environmental report should contain sufficient data to aid the Commission in its development of an independent benefit-cost analysis covering the factors specified.

The environmental report must further include a discussion of the status of compliance of the facility with applicable environmental quality standards and requirements that have been imposed by Federal, State, and regional agencies having responsibility for environmental protection. In addition, the environmental impact of the facility should be fully discussed with respect to matters covered by such standards and requirements irrespective of whether a certification from the appropriate authority has been obtained (including, but not limited to, any certification obtained pursuant to Section 401 and any discharge permit obtained pursuant to Section 402 of the Federal Water Pollution Control Act, as amended). While compliance with NRC standards and criteria pertaining to radiological effects will be necessary to meet the licensing requirements of the Atomic Energy Act, the benefit-cost analysis for the purposes of the National Environmental Policy Act must consider the radiological effects together with a broad range of other environmental effects of the facility.

3. Preparation of Environmental Reports

a. Purpose of This Guide

The Commission's regulations in 10 CFR Part 51 provide only general information concerning the content of an applicant's environmental report. This guide has been prepared to provide specific and detailed guidance for the preparation of environmental reports for uranium mills. Where appropriate, similar information should also be provided for support or ancillary facilities (e.g., heap leach and ion exchange facilities) both within and outside the mill site boundary.

The guide identifies information needed by the NRC staff to assess the potential environmental effects of the proposed uranium mill and directly associated mining activities and establishes a format acceptable to the staff for its presentation. Conformance with this standard format, however, is not required. Use of the format of this guide will help ensure the completeness of the information provided, will assist the NRC staff and others in locating the information, and will aid in shortening the time needed for the review process.

The environmental report and the application, as discussed in Regulatory Guide 3.5, "Standard Format and Content of License Applications for Uranium Mills," should be submitted together. These documents provide the basis for the licensing action on the facility.

b. Scope of This Guide

In order to cover a wide variety of anticipated situations, the scope of this guide is comprehensive. In some instances, requests for specific information may not be applicable to a particular mill or site. The applicant should identify those areas where the information requested is not relevant to the particular mill under consideration. If any topics in this guide relate to information not available at the time the report is prepared, the applicant should indicate when the information will be available.

c. Presentation of Information

The applicant should strive for clear, concise presentation of the information provided in the environmental report. Each subject should be treated in sufficient depth and with sufficient documentation* to permit the Commission to evaluate the extent of the environmental impact independent of the applicant's analysis.

When an evaluation of information or data is necessary to show compliance with a regulation, the applicant should clearly state the conclusion of the evaluation and present the analyses and supporting data in sufficient detail to permit an independent reviewer to verify this result. Tables, line drawings, and photographs should be used wherever they contribute to the clarity and brevity of the report. The number of significant figures stated in numerical data should reflect the accuracy of the data. Descriptive and narrative passages should be concise. In cases where test results are needed to support conclusions, test data, procedures, techniques, and equipment used to perform tests should be included.

Pertinent published information relating to the site, the mill, and its surroundings should be referenced. Where published information or assumptions are essential to evaluate specific environmental effects of the proposed activities, they should be included in summary or verbatim form in the environmental report or as an appendix to the report.**

Some of the information that should be included in the environmental report may have already been prepared by the applicant during preparation of the license application for the proposed mill. In such cases, this information (whether in the form of text, tables, or figures) should be incorporated in the environmental report, where appropriate, to provide a complete document.

The site for the mill may also be the site of the mine. If there is a proposed mine adjacent to or in the vicinity of the mill site, the applicant should consider the cumulative or synergistic effects of directly associated mining activities when preparing the environmental report relating to such a mill.

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*Documentation as used in this guide means information, supporting data, and statements and includes (1) references to published information, (2) citations from the applicant's experience, and (3) reference to unpublished information developed by the applicant or the applicant's consultants. Statements not supported by documentation should be identified either as information for which documentation is not available or as expressions of belief or judgment.

**The distinction between pertinent and essential hinges on the effect that the information may have in the review of potential impacts to public health and safety and the environment. Useful information that is not likely to impact public health and safety or the environment is pertinent. However, information that may reasonably be necessary for the review to ensure protection of public health and safety and the environment is essential.

CHAPTER 1. PROPOSED ACTIVITIES

This chapter of the environmental report should discuss the proposed project and the activities to be conducted as a result of the project. For example, the applicant should address such matters as ore reserves, ore-body locations, anticipated quantity of ore to be mined and milled, mining methods, plans for overburden storage and disposal, ore transport, milling processes, plans for tailings disposal and management, transport of product, operating plans and schedules, expected longevity of the project, U_3O_8 content of the ore, ore processing rate, concentrate yield, planned end use of the project areas, and surety arrangements for the eventual decommissioning of the mill and reclamation of the areas impacted.

CHAPTER 2. THE SITE

This chapter should present the basic relevant information concerning those physical, biological, human, and social characteristics of the area potentially affected by the proposed project that might be affected by the construction and operation of a uranium milling project and its associated activities in the region. To the extent possible, the information presented should reflect observations and measurements made over periods of time sufficient to allow defensible conclusions to be reached.

2.1 Site Location and Layout

A map should be provided that shows the site and its location with respect to State, county, and other political subdivisions. On detailed maps, show the location of the boundary of the proposed restricted area (10 CFR Part 20); the applicant's property; adjacent properties, including water bodies, wooded areas, and farms; nearby settlements; industrial plants, parks, and other public facilities; and transportation links (railroads, highways, waterways). Indicate total acreage owned or leased by the applicant and that part occupied by or which will be modified for the mine and mill. Indicate other existing and proposed uses of applicant's property and the acreage devoted to these uses.

Describe any plans for site modifications such as a visitors' center. A contour map of the site should also be supplied with elevation contours of an interval suitable to show significant variations of the site environs and drainage gradients. In addition, indicate if the site is in the vicinity of a flood plain. This information should be supplied as separate maps, if required, for clarity.

2.2 Uses of Adjacent Lands and Waters

Indicate, within an 8-km (5-mi) radius, the nature and extent of present and projected land use (e.g., agriculture, livestock raising, dairies, pasturelands, residences, wildlife preserves, sanctuaries, hunting areas, industries, recreation, transportation) and any recent trends such as major or unexpected changes in population or industrial patterns. Note whether any other nuclear fuel cycle facilities are located or are proposed within an 80-km (50-mi) radius of the site.

Provide in tabular form for each of the 22-1/2-degree sectors centered on one of the 16 compass points, i.e., north, north northeast, etc., the distances [to a distance of 8 km (5 mi)] from the center of the site to the following:

1. Nearest cattle (or other meat animals) grazing on natural forage, with types and numbers of animals specified.

2. Nearest game animals consumed by sportsmen.

3. Nearest residence.

4. Nearest site boundary.

5. Nearest vegetable garden larger than 50 m^2 (60 yd^2) in area. The type of crop and amounts produced should be noted.

Where possible, the applicant should provide specific information on actual consumption of the meat from cattle and game animals.

Provide data on annual production and distribution of meat (kg) and truck farming produce (kg) within an 80-km (50-mi) radius from the proposed facility. Provide information on grazing season (months of year) and feeding regimens for cattle. Agricultural production, crop yield, grazing, and feeding data may be obtained from sources such as local, State, and Federal agricultural agencies, agricultural agents, and other reliable sources.

Identify the location, nature, and amounts of present and projected surface and ground-water use (e.g., water supplies, irrigation, reservoirs, recreation, and transportation) within 16 km (10 mi) of the site and the present and projected population (during the active life of the mill) associated with each use point, where appropriate.

Data on both present and projected future water use should be summarized and tabulated; users should be located on maps of legible scale. Tabulations should include:

1. Location: Include symbols shown on maps identifying the location of water users. Provide map coordinates if appropriate.

2. Distance from mill.

3. Withdrawal rate: Provide present and projected withdrawal rate (in liters per second or cubic meters per second) for each water use.

4. Return rates: Provide present and projected return rates (in liters per second or cubic meters per second), if appropriate.

5. Type of water use: Provide type of water use for each location, e.g., municipal, industrial, irrigation, stock/game watering.

6. In addition, for ground-water use: Indicate depth of wells, ground-water elevation, and drawdown rates and characterize the use of each aquifer.

7. Source and projection of water-use estimates: Where use rates are anticipated to change over the life of the project and beyond, indicate projections and the source of the projection information. Sources for such projections may be available from users or planning agencies at different levels of government.

For items 3 and 4 above, if use varies significantly seasonally, indicate monthly values.

Provide data on the annual recreational and commercial fish catch from waters within an 8-km (5-mi) radius of the site. Report the catch by principal species, location, and amount used for human consumption (note amounts consumed locally).

2.3 Population Distribution

Population data presented should be based on the most recent census data. On a map of suitable scale that identifies places of significant population grouping, such as cities and towns, within an 80-km (50-mi) radius, concentric circles should be drawn with the mill at the center point, at distances of 0.1, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0 and 80.0 kilometers. The circles should be divided into 22-1/2-degree sectors with each sector centered on one of the 16 compass points (with reference to true north, i.e., north-northeast, northeast, etc.). A table (see table in Appendix A) appropriately keyed to the map should provide the current residential population within each area for the expected first year of mill operation and census years through the anticipated life of the mill. The tables should provide separate and cumulative population totals for each sector and annular ring. Distance to the nearest residence should be noted for each sector. The basis for population projections should be described.

Descriptive material should include tables giving the population of neighboring schools, plants, hospitals and residential areas within 8 km (5 mi). Visitor statistics for such areas as sports facilities, residential areas, and parks within 8 km (5 mi) of the project site(s) should also be included.

2.4 Regional Historic, Archeological, Architectural, Scenic, Cultural, and Natural Landmarks

Areas valued for their historic, archeological, architectural, scenic, cultural, or natural significance may be affected. The environmental report should include a brief discussion of the historic, scenic, archeological, architectural, cultural, and natural significance, if any, of the mill site and nearby areas with specific attention to the sites and areas listed in the National Registry of Natural Landmarks and properties included in or eligible for inclusion in the National Register of Historic Places.

The National Registry of Natural Landmarks appears in 37 FR 1496. The National Register of Historic Places is published annually in the Federal Register. General guidance on the treatment of historic, archeological, architectural, and cultural features can be obtained by reference to the Advisory Council on Historic Preservation Regulations, 36 CFR Part 800, "Protection of Historic and Cultural Property," and by consulting the Cultural Programs Division of the nearest regional office of the National Park Service and the relevant State Historic Society or its equivalent.

The applicant should submit a copy of the report on the archeological and historical artifact survey of the proposed site and of any areas to be disturbed by mill related activities. With respect to Indian lands, this survey should be performed with special attention to sacred areas and other special features uncovered from the oral history of the appropriate Indian tribe(s).

The environmental report should identify those properties included in or eligible for inclusion in the National Register of Historic Places located within the area of the project's potential environmental impact. Also, the applicant should discuss its consultation with the appropriate State Historic Preservation Officer concerning the identification of properties included in or eligible for inclusion in the National Register of Historic Places. The environmental report should contain evidence of this contact with the Historic Preservation Officer for the State involved, including a copy of the Officer's comments concerning the effect of the undertaking on historic, archeological, architectural, and cultural resources.

State whether new roads, pipelines, and utilities connected with the proposed mill will pass through or near any area or location of known historic, scenic, cultural, natural, archeological, or architectural significance.

2.5 Geology and Soils

Describe the major geological and soils aspects of the site and its environs. The discussion should note the stratigraphy, structure, and tectonic history. Comment on regional continuity, faulting, dip, and strikes of water-bearing formations that will be affected. An inventory of economically important minerals and energy-related deposits, in addition to the uranium ore, should be included. Any unique mineralogical or paleontological deposits of particular scientific interest should also be noted. Any effect that planned operations might have on the future availability of other mineral resources should be noted.

Detailed geological data at building sites and in the vicinity of tailings or other effluent impoundments, sanitary landfills, spoil disposal areas, and sewage disposal facilities should be included. These data should include strike and dip and lateral and vertical distribution of permeable layers, shales, and clays, and data on any fault, fracture, or joint pattern that may exist. Locations of local outcroppings where seepage from landfills, dumps, impoundments, and sewage facilities is likely to occur should be noted.

The location of ground water with respect to tailings disposal areas, spoil dumps, liquid impoundments, sanitary landfills, and sewage disposal facilities is important for the assessment of possible ground-water contamination. The discussion should include a statement concerning the hydraulic properties (such as permeability and porosity) of the materials between the ground water and these facilities.

2.6 Seismology

Discuss the seismicity (including history) of the region. Where possible, associate seismic events with tectonic features identified in the geology discussion. Furnish a regional earthquake epicenter map showing site location.

2.7 Hydrology

The effects of mine, mill, and other project facilities construction and operation on adjacent surface and ground waters are of prime importance. The applicant should describe, in quantitative terms, the physical, chemical, biological, radiological and hydrological characteristics, the typical seasonal ranges and averages, and the historical extremes for surface- and ground-water bodies. Information relating to water quality characteristics should include measurements made on or in close proximity to the site.

Information should be presented in sufficient detail to allow an independent staff review of the effects of construction and operation on both resources. Data should be presented in metric units as specified by the U.S. Geological Survey.*

2.7.1 Ground Water

Describe the hydrology of the region that affects the local ground-water aquifers, formations, sources, and sinks. Describe the recharge potential of the immediate plant area, including vertical and horizontal permeabilities of the natural and modified terrain, as well as that of tailing disposal areas. Indicate gradients and seasonal variations in ground-water levels beneath the site. Furnish sufficient site-specific data for the evaluation of the effects of construction and operation of the facility on established ground-water tables and usage. This is especially important for consideration of dewatering operations in associated mines.

Descriptions of the major aquifers in the area should include piezometric contour maps, hydraulic gradients, permeabilities for representative geologic features, total and effective porosities, bulk density estimates, storage coefficients, dispersion and distribution (sorption) coefficients, descriptions of pertinent geologic formations and soil types, including formation depth throughout the site and to the nearest downgradient well or water body, chemical and radiological properties, and time histories of ground-water fluctuations.

The applicant should provide data concerning any drawdown of ground water that may be caused by withdrawals from neighboring major industrial, agricultural, or municipal wells.

2.7.2 Surface Water

Describe the location, size, shape, and other hydrologic characteristics of water bodies in the environs of the site. Surface-water descriptions for receiving streams should include the channel shape, slope, roughness coefficient, sediment concentrations (suspended), flow records (at nearest gauges), and dispersion coefficients; for ponds and lakes the geometry of the bed, wind currents, and suspended solids (sediment) concentration.

Include a description of upstream and downstream river control structures, and provide a topographic map showing the major hydrologic features.

2.8 Meteorology

This section should provide a description of the meteorological diffusion characteristics of the site and its surrounding area. The description should include the use of data collected for at least one annual cycle from an onsite or nearby local meteorological station, plus examination of additional regional meteorological information. Sufficient data should be included to permit independent staff evaluation and assessment of atmospheric diffusion characteristics.

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*A. M. Orellama and S. M. Lang, "Conversion Factors: SI Metric and U.S. Customary Units," U.S. Geological Survey, Branch of Distribution, 1200 S. Eads St., Arlington, Virginia 22202.

The following data concerning site meteorology from meteorological measurements taken onsite and at nearby representative stations should be presented:

1. Quarterly and annual wind rose presentation for the 16 compass directions.

2. Quarterly and annual wind speed, wind direction, and atmospheric stability data in joint frequency form at heights representative of effluent releases.

3. Total precipitation and evaporation by month.

This information should be fully documented as to validity of its representation of expected long-term conditions at and near the site.

Present the joint wind speed-stability-direction frequencies (in item 2 above) in tabular form, giving the frequencies as fractions when using 5-year National Weather Service summaries or as number of occurrences when using only 1 or 2 years of onsite data. The data should be presented for each of the 16 compass directions, and the stability categories should be established to conform as closely as possible with those of Pasquill.* In addition, the annual average inversion height should be provided from other nearby weather stations.

Guidance on acceptable onsite meteorological measurements and data format for nuclear reactors is presented in Regulatory Guide 1.23, "Onsite Meteorological Programs." Staff guidance should be requested for adaptation of relevant portions of this document to the specific mill project. See Appendix A of this regulatory guide for appropriate format for meteorological data.

In addition, this section should provide a discussion of general climatology, the existing levels of air pollution and their effects on site operations, the relationship of the meteorological data gathered on a regional basis to local data, the impact of the local terrain and large lakes and other bodies of water on meteorological conditions in the area, and the occurrence of severe weather in the area and its effects. Data on diurnal and monthly averages and extremes of temperature and humidity should also be provided.

2.9 Ecology

In this section, the applicant should describe the biota (both flora and fauna) in the vicinity of the site, their habitats, and their distribution. This initial inventory should reveal certain organisms which, because of their importance to the community, should be given specific attention. A species is "important" (for the purposes of this guide) if a specific link exists between the facility and the species and if one or more of the following criteria applies: (a) the species is commercially or recreationally valuable, (b) the species is threatened or endangered,* (c) the species affects the well-being of some important species within criteria (a) or (b), or (d) the species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides or chemical pollutants in the environment.

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*F. Pasquill, "The Estimation of Windborne Material," Meteorological Magazine, Vol. 90, pp. 33-49, 1961.

The information should be presented in two separate subsections: "Terrestrial Ecology" and "Aquatic Ecology." The sources of information should be identified. As part of this identification, present a list of pertinent published material dealing with the ecology of the region. Locate and describe any ecological or biological studies of the site or its environs currently in progress.

The initial inventory should establish the identity of the majority of terrestrial and aquatic organisms on or near the site and their relative (qualitative) abundances. The applicant should identify the "important" species from this list and discuss in detail their number and geographic distribution. The discussion should include species that migrate through the area or use it for breeding grounds. Special attention should be given to the relative importance of the site area as compared to the total regional ecosystem (potential or exploited). Any additional inventories should be reserved for those species identified as critical.

The applicant should provide data on the count and distribution of important domestic fauna, in particular, cattle, sheep, and other meat animals that may be included in the biological pathway that ultimately could involve the exposure of humans to radionuclides. Important game animals should receive similar treatment. A description of marketing or consumption patterns for livestock or game should also be submitted, including livestock consumed by families with grazing rights in the mill vicinity and the extent of sales to local or national markets. A map that shows the distribution of the principal flora communities should be provided. These plant communities should be characterized by predominant species, successional stage, percent ground cover and annual yield (in animal unit months or other acceptable units).

The discussion of species-environment relationships should include descriptions of area usage (e.g., habitat, breeding, etc.) for important species; it should include life histories of important regional animals and aquatic organisms, their normal seasonal population fluctuations, and their habitat requirements; and it should include identification of food chains and other interspecies relationships, particularly when these may contribute to predictions or evaluations of the impact of the facility on the regional biota.

Information on the soils of the project area(s) should include soil map(s), details of the physical and chemical characteristics of typical soil profiles with respect to potentially toxic elements and compounds, and land capacity classification. The site(s) soils should be evaluated with respect to suitability as sources of topsoil materials during the period of interim stabilization and final reclamation.

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* In the writing and reviewing of environmental reports, specific consideration should be given to possible impact on any species (or its habitat) that has been determined by the Secretary of the Interior and the Secretary of Commerce to be endangered or threatened with endangerment. New terminology defining "endangered or threatened with endangerment" has been promulgated in Public Law 93-205, 87 Stat. 884.

Identify any definable preexisting environmental stresses from sources such as pollutants, as well as pertinent ecological conditions suggestive of such stresses. The status of ecological succession should be described. Discuss the histories of any infestations, epidemics, or catastrophes that have had a significant impact on regional biota.

2.10 Background Radiological Characteristics

Regional radiological data should be reported, including both natural background radiation levels and results of measurements of concentrations of radioactive materials occurring in important biota, in soil and rocks, in air, and in regional surface and local ground waters. These data, whether determined during the applicant's preoperational surveillance program (see Section 6.1.5) or obtained from other sources, should be referenced.

2.11 Background Nonradiological Characteristics

Regional nonradiological characteristics, particularly those that are similar to expected site-related effluents, should be reported. Data should include such parameters as heavy metals and other potentially toxic substances, atmospheric pollutants, and dusts that could affect water or air quality. Other regional sources of these same materials should be noted along with a discussion of the possible contribution to levels found at the facility site.

2.12 Other Environmental Features

For certain sites, some relevant information on the mill or mine environs may not clearly fall within the scope of the preceding topics. Submission of additional information may be appropriate with respect to some environmental features in order to reflect the value of the site and site environs to important segments of the population. Such information should be included here.

CHAPTER 3. THE MILL AND MINE(S)

The operating mill and any directly associated mine(s) adjacent to or in the vicinity of the mill should be described in this chapter. The mill and mine effluents and related systems that interact with the environment should be described in detail sufficient to allow the reviewer to independently assess the combined environmental effects presented in this chapter of the environmental report.

3.1 Site* Area

A map of the site area should be included; it should clearly show the following:

1. The location of the site boundary.

2. The location and orientation of principal structures within the site area. Principal structures should be identified as to function, e.g., mines, ore crushing structures, chemical separation and storage, ore stock piles, waste rock dumps, tailings disposal areas, retention and settling ponds, explosive magazines, housing areas, administration buildings, yellowcake storage areas, parking lots.

3. The boundary lines of any restricted areas, access to which are to be controlled by fences or other means.

4. A scale that will permit the measurement of distances with reasonable accuracy.

5. True north.

3.2 External Appearance of Mill

The building layout and plant profile should be shown to scale by line drawings or other illustrative techniques. The architectural design and efforts to make the structures and grounds esthetically pleasing should be noted.

3.3 Mill Circuit

The entire mill process or circuit should be quantitatively and qualitatively described in sufficient depth to permit confirmation of the quantities and constituents of all gaseous, liquid, and solid wastes and effluents generated in the process. The following should be included:

1. A flow diagram of the process or circuit.

2. A material balance diagram.

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*Site means the contiguous real estate on which the mine and mill are located.

3. Description of any water recycle systems.

4. Water balance diagram for the entire mining/milling project.

3.4 Sources of Mill Wastes and Effluents

Clearly identify the location of release points for all gaseous (include stack heights), liquid, and solid wastes and effluents, including bulk storage locations, i.e., piles of ore or tailings or overburden dumps. Specify quantities, concentrations, and physical, chemical, and radiological characteristics of all materials released. Average and maximum release rates should be included plus all pertinent supporting information such as assumptions and computational methods used. The quantities and concentrations of radioactive and nonradioactive materials that will be released into the environs should be compared with State and other applicable standards.

Suggested formats for supplying this material on radioactive emissions are included as Appendix B of this guide. The tables supplied by the applicant should not be limited to the examples listed, however.

3.5 Controls of Mill Wastes and Effluents

Provide a description of mill waste and effluent control systems and equipment for minimizing to as low as is reasonably achievable the quantities of materials released into the environment. Identify the operating efficiency of such systems and equipment in relation to current best methods for controlling milling wastes and effluents. Also, identify the factors that affect these efficiencies, and describe the operating practices to be pursued during the life of the proposed project.

For waste retention systems, a design analysis of the integrity of the proposed systems should be provided. This should include:

1. Drawings showing the layout in plan, typical cross sections of all embankments showing proposed design and, if applicable, anticipated future extensions, and other pertinent design details. Embankment designs should include information on heights, top width, side slopes, freeboard, seepage control, and protection of embankment surfaces as well as foundation design. See Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills."

2. The results of soil tests, geologic exploration, foundation materials stability investigations, as well as characteristics of fill material and a description of the construction methods and specifications.

3.6 Sanitary and Other Mill Waste Systems

Describe any other nonradioactive solid or liquid waste materials, such as sanitary, laundry, and chemical laboratory wastes that may be generated during operation. Describe the manner in which they will be treated and controlled, and describe procedures for disposal.

Means for control and treatment of all systems subject to effluent limitation guidelines and standards of performance under the Federal Water Pollution Control Act (FWPCA) should be described.

The applicant should (a) describe any other airborne effluents (e.g., from diesel engines, gas turbines, heating plants, incinerators) created during project operation, (b) estimate the frequency of release and describe how they will be treated before release to the environment, and (c) estimate the total quantity of pollutants to be discharged annually.

3.7 Mining Activities

This portion of the report should contain a thorough description of the interrelated mining activities including:

1. Topographical maps showing locations and areas to be mined and haulage and access roads.
2. A description of the mining method(s) to be employed, including any dewatering activities and associated effluents.
3. A description of the method(s) for accumulating and storing wastes in order to minimize esthetic and other effects.
4. Identification and source terms of all sources of effluents associated with mining activities (e.g., radon and particulate emissions, dust from haulage, storage activities), including release rates and concentrations and their physical and chemical characteristics.
5. A description of methods to minimize and control releases of effluents into the environs.
6. Any other information that might be helpful in assessing the environmental effects connected with the mining project.

CHAPTER 4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION, MILL CONSTRUCTION, AND MINE OPENING

The construction of a uranium mill and the openings of related mines will inevitably affect the environment; some of the effects will be adverse and some may be beneficial. Effects are considered adverse (1) if environmental change or stress causes a valuable or otherwise important biotic population or natural resource to be less safe, less healthy, less abundant, less productive, or less esthetically or culturally pleasing; (2) if the change or stress reduces the diversity and variety of individual choice, the standard of living, or the extent of sharing of life's amenities; or (3) if the change or stress tends to lower the quality of renewable resources or to impair the recycling of depletable resources.

In the applicant's discussion of adverse environmental effects, it should be made clear which of these adverse effects are considered unavoidable and subject to later amelioration and which are regarded as unavoidable and irreversible. Those effects that represent an irretrievable commitment of resources should receive detailed consideration in Section 4.2. In the context of this discussion, "irretrievable commitment of resources" alludes to natural resources and means a permanent impairment of these, e.g., loss of wildlife habitat; destruction of nesting, breeding, or nursing areas; interference with migratory routes; loss of valuable or esthetically treasured natural areas; and use of nonrenewable resources.

4.1 Site Preparation and Construction

The applicant should organize the discussion in terms of the effects of site preparation (including mine opening) and mill construction on both land use and water use. The applicant should consider consequences to both human and wildlife populations and indicate which are unavoidable and irreversible according to the categorization set forth above.

In the land-use discussion, describe how construction activities may disturb the existing terrain and wildlife habitats. Consider the effects of such activities as creating building material supply areas; building temporary or permanent roads, bridges, or service lines; disposing of trash; excavating; and land filling. Provide information bearing on such questions as what is the total number of acres disturbed, at which locations, over what time periods, will there be dust or smoke problems, what type and amount of explosives will be used, where, and how often.

Indicate proximity of human populations and identify undesirable impacts on their environment arising from noise, disruption of stock grazing patterns, inconvenience because of the movement of people, material, machines, including activities associated with any provision of housing, transportation, and educational facilities for workers and their families. Describe any expected changes in accessibility of historical and archeological sites in the region. Discuss measures designed to mitigate or reverse undesirable effects, such as erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats.

The discussion should also include any effects of site preparation and construction activities whose consequences may be beneficial to the region.

The discussion of water use should describe the impact of site preparation and construction activities on area water sources. Such activities would include mine dewatering, diversion of streams, and placement of fill material in water. The applicant should describe the effects of these activities on fish and wildlife resources, water quality, water supply, downstream use of water, and esthetics, as applicable. Describe measures to control pollution to mitigate undesirable effects and improve habitats.

4.2 Resources Committed

Discuss any irreversible and irretrievable commitments of resources (e.g., commitment of land, consumptive water use, and destruction of biota) that are expected should site preparation and mine opening and mill construction proceed. Such use should be evaluated in terms of its relative and long-term net impacts, as well as its absolute impacts. (See Section 5.6 of this guide for more detailed consideration.)

CHAPTER 5. ENVIRONMENTAL EFFECTS OF MILLS AND MINE OPERATION

This chapter should describe the interaction of the mill and mine (discussed in Chapter 3) and the environment (discussed in Chapter 2) during the operating phase of the project. To the extent possible, material presented in Chapters 2 and 3 does not need to be repeated. Measures planned to reduce any undesirable effects of the total project on the environment should be described in detail.

In the discussion of environmental effects, as in Chapter 4, effects that are considered unavoidable but either inherently temporary or subject to later amelioration should be clearly distinguished from those regarded as unavoidable and irreversible. Those effects that represent an irretrievable commitment of resources should receive detailed consideration in Section 5.6.

The impacts of operation of the proposed activity should be, to the fullest extent practicable, quantified and systematically presented. In the discussion of each impact, the applicant should make clear whether the supporting evidence is based on theoretical, laboratory, onsite, or field studies undertaken on this or on previous occasions. The source of each impact (the plant subsystem, waste effluent) and the population or resource affected should be made clear in each case. The impacts should be distinguished in terms of their effects on surface water bodies, ground water, air, land, land use, ecological systems, and important plants and animals.

Finally, the applicant should discuss the relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity. As used in this guide, "short-term" refers to the operating life of the proposed facility and "long-term" refers to time periods extending beyond this life. The applicant should assess the action for cumulative and projected long-term effects from the point of view that each generation is trustee of the environment for each succeeding generation.

Principal parameters for the assessment of radiological impacts from proposed activities should be presented in the format of Appendix B.

5.1 Radiological Impact on Biota Other Than Humans

In this section the applicant should consider the impact on biota other than humans attributable to the release of radioactive or chemical materials from the facility. The biota to be considered are those species of local flora and local and migratory fauna defined as "important" in Section 2.9. Since the region may contain many important species, the applicant should concentrate any efforts on those important species whose terrestrial and aquatic habitats provide the highest potential for radiation exposure.

5.1.1 Exposure Pathways

The various possible pathways for radiation exposure of the important local flora and local and migratory fauna should be identified and described in textual and flow-chart format. The pathways should include the important routes of radionuclide translocation (including food chains leading to important species) to organisms or sites.

5.1.2 Effluents in the Environment

In Sections 3.4 and 3.7, the radionuclide and chemical concentrations in the liquid and gaseous effluents discharged from the site are listed. In this section, the applicant should consider how these effluents are quantitatively distributed in the environment. Specifically, estimates should be provided for the concentration (a) in any water sources, (b) on land areas, and (c) on vegetation (on a per unit area basis) in the environs.

If there are other components of the physical environment that may become contaminated and thus result in the exposure of living organisms to radiation, they should be identified and their radioactivity burden estimated. In addition, information concerning any cumulative buildup of radionuclides in the environment should be presented and discussed. A summary of data, assumptions, and models used in determining radioactivity concentrations and burdens should be provided.

From considerations of the exposure pathways and the distribution of radioactivity released into the environs, the applicant should estimate the maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna. Values of bioaccumulation factors used in preparing the estimates should be based on site-specific data if available; otherwise, values from the literature may be used. The applicant should tabulate and reference the values of bioaccumulation factors used in the calculations.

5.2 Radiological Impact on Humans

In this section the applicant should consider the radiological effects of operations and transportation of radioactive materials on human beings. Estimates of the radiological impact on humans via various exposure pathways should be provided.

5.2.1 Exposure Pathways

The various possible pathways for radiation exposure of humans should be identified and described in textual and flow chart format.

Discuss any exposure pathways, if they exist, involving radionuclide accumulation in specific components of the environment.

5.2.2 Liquid Effluents

Estimate the expected annual average concentrations of radioactive nuclides (listed in Sections 3.4 and 3.7) in receiving water at locations where water is consumed or otherwise used by human beings or where it is inhabited by biota of significance to human food chains. Specify the dilution factors used in preparing the estimates and the locations where the dilution factors are applicable. Consideration should be given to the absence of mixing and dilution because of factors such as channeling.

Determine the expected radionuclide concentrations in aquatic and terrestrial organisms significant to human food chains. Use the bioaccumulation factors given in Section 5.1.2 or supply others as necessary.

Using the above information and any other necessary supporting data, calculate the total annual body and significant organ doses (millirems) to individuals in the population (discussed in Section 2.3) from all exposure pathways related to receiving water, i.e., all sources of internal and external exposure. Provide, as an appendix, details of the models and assumptions used in these calculations.

5.2.3 Airborne Effluents

From release rates of airborne radioactivity and meteorological data (Sections 3.4, 3.7, and 2.8), estimate total annual body and significant organ doses (millirems) to individuals exposed at the point of maximum ground-level concentrations offsite, individuals exposed at the site boundary in the direction of the prevailing wind, individuals exposed at the site boundary nearest to the sources of emission, and individuals exposed at the residence expected to receive the highest dose commitments. Assume annual average meteorological conditions. Identify locations of points of release (e.g., stacks, roof vents, tailings ponds and beach areas, and ore storage areas) used in calculations.

Estimate deposition of radioactive materials on food crops and pasture grass and any bioaccumulation in the human food chain. Estimate total annual body doses (millirems) and significant annual doses received by other organs via such potential pathways.

Provide an appendix describing the models used in these calculations.

5.2.4 Direct Radiation

The applicant should provide an estimate of the maximum annual external dose (millirems) that would be received by an individual at the nearest site boundary from direct radiation. Provide an appendix describing the models and assumptions used in these calculations.

5.2.5 Summary of Annual Radiation Doses

The applicant should provide estimates of the maximum annual doses (millirems) that could be received via all pathways by an individual at the site boundary and at the nearest residence.

The applicant should also present a table that summarizes the estimated radiation dose to the regional population (within 80-km) from mill- and mine-related sources using values calculated in previous sections. The tabulation should include (a) the total annual doses (man-rems) to the population (discussed in Section 2.3) from all water-related pathways and (b) the total annual doses (man-rems) to the population attributable to airborne effluents.

5.3 Chemical Impacts on Humans

In this section, the specific concentrations of nonradioactive wastes in effluents at the points of discharge should be compared with natural ambient concentrations without the discharge and also compared with applicable standards. The projected effects of the effluents for both acute and chronic exposure of human beings (including those resulting from any long-term buildup in soils and sediments and in the biota) should be identified and discussed. Dilution and mixing of discharges into the receiving environs should be discussed in detail, and estimates of concentrations at various relevant distances from the point of discharge should be provided that relate to factors such as dilution, habitations, wells, and water intakes. The effects on humans from changes in terrestrial and aquatic environments from chemicals that contaminate ground water should be included.

5.4 Effects of Sanitary and Other Waste Discharges

Describe and discuss the environmental impact associated with sanitary and other mill waste systems discussed in Section 3.6.

5.5 Other Effects

The applicant should discuss any effects of operation that do not clearly fall under any single topic of Sections 5.1 through 5.4. These may include changes in land and water use at the project site, interaction of the facility with other existing or projected neighboring facilities, effect of ground-water withdrawal on ground-water resources in the vicinity of the mine and mill, effects of construction and operation of roads, transmission corridors, and railroads, effects on fish and wildlife resource usage, effects of changes in surface-water availability on biotic populations, and disposal of solid and liquid wastes other than those already discussed.

5.6 Resources Committed

Any irreversible and irretrievable commitment of resources resulting from mine and mill operation should be discussed. This discussion should include both direct commitments, such as depletion of uranium resources; irreversible environmental losses, such as destruction of wildlife habitat; and consumptive water use.

In this discussion, the applicant should consider resources used from the viewpoints of both relative impacts and long-term net effects. As an example of relative impact assessment, the loss of a few animals of a given species could represent quite different degrees of significance, depending on the total population in the immediate region. Such a loss in the case of a small local population, however, could be less serious if the same species were abundant in neighboring regions. Similarly, land use that precludes other highly desirable land uses should be evaluated in terms of the total amount of such land in the environs. These relative assessments should accordingly include statements expressed in percentage terms (a) in which the amount of expected resource loss is related to the total resource in the immediate region and (b) in which the total resource in the immediate region is related to that resource in surrounding regions. The latter should be specified in terms of areas and distances from the site.

CHAPTER 6. EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

The purpose of this chapter is to describe in detail the means by which the applicant collected the baseline data presented in other chapters and to describe the applicant's plans and programs for monitoring the impacts of the proposed activities on the environment.*

Section 6.1 addresses the measurement of preexisting characteristics of the site and the surrounding region. This program should establish a reference framework for assessing subsequent environmental effects attributable to the proposed activity and for use as baseline reference data at the time of site decommissioning.

The applicant's attention is directed to two considerations pertinent to Section 6.1. First, the term "preexisting" refers to the characteristics of the site prior to any mining-related activities. A given characteristic or parameter may or may not require assessment prior to site disturbance and mill construction, depending on whether that particular characteristic may be altered at these stages. Second, in most instances this guide indicates the specific environmental effects to be evaluated; consequently, the parameters to be measured will be apparent. In some cases, it may be advisable to establish a monitoring program based on the applicant's own identification of potential or possible effects and to provide the underlying rationale for such a program. Accordingly, the applicant should carefully review the plans for measurement of preexisting conditions to ensure that these plans include all factors that must be subsequently monitored as discussed in Section 6.2.

Sampling design, frequency, methods (including calibration and checks with standards), and instrumentation for both collection and analysis should be discussed as applicable.**

In all cases, the applicant should estimate the statistical validity of any proposed sampling program. Information should be provided on instrument accuracy, sensitivity, and (especially for highly automated systems) reliability. Where standard analytical or sampling techniques can be identified, they should be so identified and referenced.

For quantitative descriptions of samples collected within areas and for periods of interest, descriptive statistics should include, unless justifiably omitted, the mean, standard deviation, standard error, and a confidence interval for the mean. In each case, the sample size should be clearly indicated. If diversity indices are used to describe a collection of organisms, the specific diversity indices used should be stated.

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[*] See Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills."

[**] See Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment."

6.1 Applicant's Preoperational Environmental Programs

The programs for collection of initial or baseline environmental data prior to submittal of the license application should be described in sufficient detail to make it clear that the applicant has established a thorough and comprehensive approach to environmental assessment. The description of these programs should be confined principally to technical descriptions of instrumentation, frequency and duration, technique, and procedures.

Where information from the literature has been used by the applicant, it should be concisely summarized and documented by reference to original data sources. Where the availability of original sources that support important conclusions is limited, the applicant should provide either extensive quotations or references to accessible secondary sources.* In all cases, information derived from published results should be clearly distinguished from information derived from the applicant's field measurements.

6.1.1 Surface Water

If a body of surface water may be affected by the proposed activities, the applicant should describe the programs by which the background condition of the water and the related ecology were determined. If a natural water body has already been subjected to environmental stress from pollutant sources, the nature of this stress and its consequences should be evaluated. The applicant should estimate the potential quality of the affected water body.

6.1.2 Ground Water

In those cases in which the proposed activities may potentially affect quality or quantity of local ground water, the program leading to assessment of potential effects should be described.

6.1.2.1 Physical and Chemical Parameters. The properties and configuration of the local aquifer will have been defined in sufficient detail (in Section 2.7) to permit a reasonable projection of effects of proposed activities on the ground water. Methods for obtaining information on ground-water levels and ground-water quality should be described.

6.1.2.2 Models. Models may be used to predict such effects as changes in ground-water levels, dispersion of contaminants, and eventual transport through aquifers to surface water bodies and downgradient wells. The models should be described and supporting evidence for their reliability and validity presented.

6.1.3 Air

The applicant should describe the program and identify sources for obtaining information on local air quality and local and regional meteorology.

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* Any reports of work (e.g., ecological surveys) supported by the applicant that are of significant value in assessing the environmental impact of the facility should be included as appendices or supplements to the environmental report unless these reports are otherwise generally available.

6.1.3.1 Meteorology. The applicant should identify sources of meteorological data used in the atmospheric transport models and reported in Section 2.8. Locations and elevations of observation stations, instrumentation, and frequency and duration of measurements should be specified both for the applicant's measuring activities and for activities of governmental agencies or other organizations on whose information the applicant intends to rely. Guidance for an acceptable meteorological measurement program for nuclear reactors is presented in Regulatory Guide 1.23 (Safety Guide 23), "Onsite Meteorological Programs." See Appendix C for the format for reporting meteorological data. The applicant's description should show the basis for predicting such effects as the dispersion of airborne effluents and should present the methodology for gathering baseline data.

6.1.3.2 Models. Any models used by the applicant, either to derive estimates of basic meteorological information or to estimate the effects of effluents, should be described in detail and their validity and accuracy discussed. Staff guidance should be sought in adapting existing guidance to the particular effluents from uranium mines and mills.*

6.1.4 Land

Data collection and evaluation programs concerning the terrestrial environment of the proposed mill should be described and justified with regard to both scope and methodology.

6.1.4.1 Geology and Soils. Those geological and soil studies designed to determine the environmental impact of the construction or operation of the mine/mill should be described. The description should include identification of the sampling pattern and the justification for its selection, the sampling method, holding periods, preanalysis treatment, and analytic techniques. Other geological and soil studies (e.g., those conducted in support of safety analyses) should be briefly summarized and reference made to the relevant reports for a more detailed presentation.

6.1.4.2 Land Use and Demographic Surveys. The applicant should describe its program for identifying the actual land use in the site environs and for acquiring demographic data for the region as reported in Section 2.3.

Sources of information should be identified. Methods used to forecast probable changes in land use and demographic trends should be described.

6.1.4.3 Ecological Parameters. In this section, the applicant should discuss the program used to assess the ecological characteristics of the site, with primary reference to important biota identified in Section 2.9.

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*For example, see Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors."

6.1.5 Radiological Surveys*

This section of the environmental report should discuss the methods used to determine the preoperational radiation levels at the site and environs and the concentrations of radionuclides in important local and regional biota, soil, sediment, vegetation, air, and surface and ground waters.

6.2 Applicant's Proposed Operational Monitoring Programs

The applicant should present the proposed operational monitoring program for planned operations. Review of this description will be facilitated if the applicant includes maps of proposed observation sites and tabular presentation of summary descriptors of such factors as sample collection and analysis frequency, type of sampling, method of collection, analytic method, preanalysis treatment, instrumentation, and minimum sensitivities. The discussion should include the justification for the choice of sampling sites, analyses, and sampling frequencies. The program description should be explicit with respect to the parameter limits that are not to be exceeded under normal operating conditions and with regard to the actions planned in the event the limits are exceeded.

6.2.1 Radiological Monitoring*

The applicant's operational monitoring program for radiological effects should be described both for the mine and mill effluent monitoring program and for the environmental monitoring program.

6.2.1.1 Mill Effluent Monitoring. Describe the proposed effluent monitoring program for liquid and airborne effluents. Discuss the sensitivity limits for detecting radioactivity corresponding to routinely expected release rates. List the effluent streams, if any, that will not be monitored and provide a brief rationale for the absence of monitoring. Also, provide criteria for setting threshold levels for corrective action and describe the actions to be taken if these levels are exceeded.

6.2.1.2 Environmental Radiological Monitoring. The operational monitoring program should be described in detail, with specific attention given to the organisms and other types of samples to be collected, sampling locations and frequency, the analyses to be performed on each sample, the analytical sensitivity (detection threshold) for each analysis, and the criteria for investigating increases of concentration of material detected in the environs.

6.2.2 Chemical Effluent Monitoring

The proposed measurement program, including instrumentation, locations, frequencies, and analytical techniques, should be fully described. The description of the program should include instrumentation sensitivity and reliability. Monitoring procedures prescribed by local, State, or Federal agencies as conditions placed on operation should be so identified.

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*Regulatory Guide 4.14 should be reviewed in connection with this section.

The criteria for setting threshold levels for corrective action should be presented. In the case of prescribed quantitative standards set by agencies, the applicable regulation should be cited. In the case of quantitative limits set by the applicant to conform to qualitative standards or restrictions, the applicant's rationale should be presented. In either case, if measurements exceed thresholds, the action to be taken should be specified.

6.2.3 Meteorological Monitoring

The applicant's program for monitoring meteorological phenomena should be described.

6.2.4 Ecological Monitoring

In the preoperational surveillance program, the applicant will have established methodology for determining the ecological characteristics of the region. The applicant should describe any additional ecological monitoring to be conducted during plant operation.

6.3 Related Environmental Measurement and Monitoring Programs

When the applicant's site lies within a region for which environmental measurement or monitoring programs are carried out by public agencies or other agencies or groups not directly supported by the applicant, any such related programs known to the applicant should be identified and discussed. Relevance of such independent findings to the proposed facility's effects should be described, and plans for exchange of information, if any, should be presented. Agencies responsible for the programs should be identified, and, to the extent possible, the procedures and methodology employed should be briefly described.

CHAPTER 7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The applicant should discuss the environmental effects of possible accidents that may occur at the mill and during transportation of materials to and from the mill, whether or not those accidents may produce an impact on the site or its environs. Analyses should be based on relevant experience and statistics from operation of similar milling and transportation operations. The statistical validity of the data should be discussed as well as the rationale for applying the data to the applicant's proposed operation. Accidents caused by both humans and natural phenomena should be addressed.

7.1 Mill Accidents Involving Radioactivity

The applicant should provide accident analyses for a spectrum of accidents that might occur ranging in severity from trivial (essentially no release of radioactivity to the environment) to very large releases. Each class within the spectrum should be characterized by an occurrence rate or probability and its potential consequences, if any. Examples of accidents resulting in large releases would be a tornado striking the mill or the failure of a waste retention system resulting from an act of nature or improper operation. Examples of accidents resulting in small releases would be a fire or explosion in a solvent extraction circuit or failure of the air cleaning system serving the yellowcake area during operation. An example of a trivial accident would be the malfunction of mill process equipment or the rupture of a vessel containing mill solutions.

7.2 Transportation Accidents

The potential environmental effects from transportation accidents involving radioactive and other hazardous materials should be evaluated. Even though the probability of such an accident may be low and its consequences small, the applicant should identify the environmental effects that might result. Adequate documentation should be presented to provide assurance that all safety requirements will be met prior to transportation of hazardous materials (e.g., spillage of hazardous chemicals, ores, fuels, yellow cake, sulfuric acid).

7.3 Other Accidents

In addition to accidents that can release radioactivity to the environs, there may be accidents that, although radioactive materials are not involved, do have consequences that affect the environment. Such accidents as chemical explosions or fires, steam boiler failures, and leakage or rupture of vessels containing toxic materials can have significant environmental impacts. These possible accidents and associated effects should be identified and evaluated.

CHAPTER 8. ECONOMIC AND SOCIAL EFFECTS OF MILL CONSTRUCTION AND OPERATION

The purpose of this chapter is to provide guidance on the information needed to assess the economic and social effects of the proposed facility. There are, of course, limitations on the extent to which all the social and economic benefits and costs of a uranium milling project can be evaluated. The wide variety of benefits and costs are not only difficult to assess, but many are not amenable to quantification or even to estimation in comparable units. Some primary benefits such as the quantity of uranium recovered are, to a degree, measurable as are the capital costs and operating and maintenance costs of the proposed facility. On the other hand, numerous environmental costs and their economic and social consequences are not readily quantified.

8.1 Benefits

The primary benefits of the proposed nuclear facility are those inherent in the value of the uranium to be recovered and the kilowatt-hours of electricity that may be produced from it.

There are other social and economic benefits that affect various political jurisdictions or interests to a greater or lesser degree. Some of these reflect transfer payments or other values that may partially, if not fully, compensate for certain services as well as external or environmental costs, and this fact should be reflected in the designation of the benefit. The following are some examples:

- Tax revenues to be received by local, State, and Federal governments.
- Temporary and permanent new jobs created and payroll (value-added concept).
- Incremental increase in regional product.
- Enhancement of recreational values.
- Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats.
- Creation and improvement of local roads, waterways, or other transportation facilities.
- Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with plant operation and technological improvements from the applicant's research program.

The applicant should discuss significant benefits that may be realized from the construction and operation of the proposed mill. Where the benefits can be expressed in monetary terms, they should be discounted to present value. In each instance where a particular benefit is discussed, the applicant should indicate, to the extent practical, who is likely to be affected and for how long. In the case of esthetic impacts that are difficult to quantify, the applicant should provide pictorial drawings of structures or environmental modifications visible to the public (refer to Section 3.2).

8.2 Costs

The economic and social costs resulting from the proposed nuclear facility and its milling project are also complex and should be appraised.

The primary internal costs are (1) the capital costs of land acquisition and improvement, (2) the capital costs of facility construction, (3) other operating and maintenance costs, including license fees and taxes, (4) plant decommissioning, tailings stabilization, and site reclamation costs, and (5) research and development costs associated with potential future improvements of the mill and its operation and maintenance. As in the case of benefits, the applicant should discount these costs to present value.

There are also external costs. Their effects on the interests of people need to be examined. The applicant should supply, as applicable, an evaluation plus supporting data and rationale regarding such external social and economic costs. For each cost, the applicant should describe the probable number and location of the population group adversely affected, the estimated economic and social impact, and any special measures to be taken to alleviate the impact.

Temporary external costs include shortages of housing; inflationary rentals or prices; congestion of local streets and highways; noise and temporary esthetic disturbances; overloading of water supply and sewage treatment facilities; crowding of local schools, hospitals, or other public facilities; overtaxing of community services; and disruption of people's lives or the local community caused by acquisition of land for the proposed site.

Long-term external costs include impairment of recreational values (e.g., reduced availability of desired species of wildlife and sport animals, restrictions on access to land or water areas preferred for recreational use); deterioration of esthetic and scenic values; restrictions on access to areas of scenic, historic, or cultural interest; degradation of areas having historic, cultural, natural, or archeological value; removal of land from present or contemplated alternative uses; reduction of regional products because of displacement of persons from the land proposed for the site; lost income from recreation or tourism that may be impaired by environmental disturbances; lost income attributable to environmental degradation; decrease in real estate values in areas adjacent to the proposed facility; increased costs to local governments for the services required by the permanently employed workers and their families. In discussing the costs, the applicant should indicate, to the extent practical, who is likely to be affected and for how long.

CHAPTER 9. DECOMMISSIONING AND RECLAMATION

The applicant should describe in depth its plans for mill decommissioning and site reclamation.

Detailed discussions should be provided for the following:

1. Plans for reclaiming and restoring lands disturbed by mining and milling activities. These plans should provide sufficient details for the staff to assess the suitability of these plans when compared to other alternatives (e.g., horizontal-vertical slope, type of cover, sources and thicknesses of cover materials, revegetation species, schedule of events from shutdown through final reclamation).

2. A technical and financial feasibility assessment on methods and costs of mill decommissioning and site reclamation, including tailings area.

3. Financial arrangements to be made (such as bonding arrangements) to ensure that adequate funds will be available for mill decommissioning, site reclamation, and restoration when operations are concluded.

CHAPTER 10. ALTERNATIVES TO THE PROPOSED ACTION

In this chapter of the environmental report, the applicant's choice of a particular mill at a particular site and the location of project structures on the site should be supported through a comparative evaluation of available alternatives. To the extent possible, the applicant should discuss all parameters for the available alternatives. The NRC will consider all available alternatives that may reduce or avoid adverse environmental, social, and economic effects expected to result from construction and operation of the proposed milling and mining project. The NRC will not specify in advance which alternatives should be selected by the applicant for consideration. The applicant should make this selection and also make clear the basis and rationale for the choices in regard to number, availability, suitability, and factors limiting the range of alternatives that might avoid some or all of the environmental effects previously identified. Particular attention should be placed on the relationship between tailings management alternatives and mill site and process alternatives.

In the discussion of tailings management alternatives, consideration should be given to the following siting, design, and operation performance objectives developed by the staff in addition to the technical criteria listed in Chapter 9:

1. Locate the tailings isolation area remote from people to reduce population exposures to the maximum extent reasonably achievable.*

2. Locate the tailings isolation area so that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable. See the EPA reference in the footnote below for additional guidance.

3. Design the isolation area so that seepage of toxic materials into the ground-water system would be eliminated or reduced to the maximum extent reasonably achievable.

4. Eliminate the blowing of tailings to unrestricted areas during normal operating conditions and prior to final reclamation.

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*See Environmental Protection Agency, "Criteria for Radioactive Waste," November 15, 1978, Federal Register (Part IX, 6560-01-M), Vol. 43, No. 221, p. 53267: Issue No. 5, Location and Waste Isolation.

CHAPTER 11. BENEFIT-COST ANALYSIS

In this chapter the applicant's benefit-cost statement should be presented. The presentation should be made in the form of a narrative with accompanying tables and charts. It should make clear what the applicant considers to be the important benefits and costs of the proposed facility and why, in the judgment of the applicant, the former outweigh the latter.

The applicant should develop criteria for assessing and comparing benefits and costs where these are expressed in nonmonetary or qualitative terms. The rationales for the selection among mill-site alternatives, as well as among subsystem alternatives, should be presented. In any case, the applicant should carefully describe any aggregation of effects and discuss in detail the trade-offs that were made in order to justify the proposed operation. If any of the benefits or costs are deleted from the applicant's analysis, the rationale for doing so should be explained. The applicant should key all the terms used in the benefit-cost analysis to the relevant sections of the environmental report.

CHAPTER 12. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

List all licenses, permits, and other approvals of construction and operations required by Federal, State, local, and regional authorities authorized to develop and enforce relevant standards for the protection of the environment.* List those Federal and State approvals that have already been received and indicate the status of matters regarding approvals yet to be obtained. For general background, submit similar information regarding approvals, licenses, and contacts with local authorities including any affected Indian tribes.

Discuss the status of efforts to obtain a water quality certification under Section 401 and discharge permits under Section 402 of the Federal Water Pollution Control Act, as amended. If not already obtained, indicate when certification is expected. If certification is not required, explain.

In view of the effects of the plant on the economic development of the region in which it is located, the applicant should also note the State, local, and regional planning authorities contacted or consulted. Office of Management and Budget Circular A-95** identifies the State, metropolitan, and regional clearinghouse that should be contacted, as appropriate.

Cite meetings held with any Federal, State, or local agency or Indian tribe authorized to develop or enforce relevant environmental standards. Also include any meetings or contacts with environmental and other citizen groups and Indian tribes and cite specific instances of the applicant's compliance with or rejection of the recommendations of these groups. Citation should also be given of efforts to locate such agencies or groups and to inform them of the possibilities and procedures for participating further in the environmental review process.

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*This list should be updated semiannually until final licensing action is taken by the NRC.

**Inquiries concerning this circular may be addressed to the Office of Management and Budget, Washington, D.C. 20503.

CHAPTER 13. REFERENCES

The applicant should provide a bibliography of all sources used in preparation of the environmental report. References cited should be keyed to the specific sections and page numbers to which they apply.

APPENDIX A

POPULATION DISTRIBUTION DATA

The population distribution should be given in the following manner:

- Sectors are marked off by the sixteen compass directions and radial distances along the compass directions up to 80 km (50 miles).
- The distances (km) should be broken up as indicated on the following page.

POPULATION DISTRIBUTION

COMPASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
DIRECTIONS	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
KILOMETERS																
1.0 - 2.0																
2.0 - 3.0																
3.0 - 4.0																
4.0 - 5.0																
5.0 - 10.0																
10.0 - 20.0																
20.0 - 30.0																
30.0 - 40.0																
40.0 - 50.0																
50.0 - 60.0																
60.0 - 70.0																
70.0 - 80.0																

APPENDIX B

PRINCIPAL PARAMETERS FOR RADIOLOGICAL ASSESSMENT

Parameter	Value
Ore quality, U_3O_8	______ %
Ore activity, U-238, U-234, Th-230, Ra-226, and Pb-210	______ pCi/g
Operating days per year (plant factor)	______ days
Ore process rate	______ tonnes/yr
Mill water throughput	______ m^3/yr
Annual average morning mixing height	______ m
Annual average afternoon mixing height	______ m
Ore Handling and Storage	
Estimated capacity of ore per delivery	______ MT
Number of deliveries	______ per day/ per week
Estimated ore dust released in delivery	______ kg/hr or MT/yr
Average grade of ore and ranges	______ %
Capacity of ore pad: final year of operation	______ MT
average during operation	______ MT
Maximum area of ore pad and height of ore storage pile	______ m^2, m
Approximate amount of ore handled per day i.e., unloaded, loaded, bulldozed, etc.	______ MT/day
Operation time of front-end loaders, hoppers, feeders, and other ore pad equipment	______ hr/day
Estimated amount of fugitive ore dust emission from handling of ore on ore pad	______ MT/yr

Dust emission control reduction factor by wetting, chemical, or other controls ____________________%

Ore storage time ____________________days

Crushers, Grinders, Rod Mills, Fine Ore Blending, Solvent Extraction, Countercurrent Decantation, Ion Exchange, and Leaching

For each piece of potential radioactive emission source equipment, report the following:*

Operation time ____________________hr/day and days/yr

Estimated dust lost to atmosphere ____________________MT/yr

Estimated radon released to atmosphere ____________________Ci/yr

Efficiency of emission control devices (effective and design) ____________________%

Estimated dust lost to atmosphere through internal ore transportation devices (e.g., conveyor belts) ____________________MT/yr

Efficiency of emission controls of internal ore transportation devices (effective and design) ____________________%

Average daily capacity of temporary bin storage (fine ore bins) ____________________MT/d

Efficiency of controls for temporary bin storage ____________________%

Yellowcake Drying and Packaging (based on last year of operation)

(Give parameter values for drying and packaging)

Processing rates
Drying ______________days/yr and hr/day
Packaging ____________days/yr and hr/day

Operation time
Drying______________days/yr and hr/day
Packaging_____________days/yr and hr/day

Efficiency of control of U_3O_8 dust released to atmosphere (design and effective)
Drying______________%
Packaging ____________%

---

[*] If change or expansion of the process is planned, provide approximate values as necessary.

Estimated U_3O_8 dust released to atmosphere

Drying ____________ MT/yr
Packaging ____________ MT/yr

Stack height(s)

Drying ____________ m
Packaging ____________ m

Recovery rate of U_3O_8 ____________ %

Yellowcake yield ____________ tonnes/yr

Yellowcake quality, U_3O_8 ____________ %

Heap Leach Piles(if applicable)

Dimensions (height, width, length) ____________ m, m, m

Volume ____________ m^3

Capacity ____________ MT

Pile activity for U-238, Th-230, Ra-226, and Pb-210 ____________ pCi/g

Fugitive dust emissions ____________ MT/yr

Control efficiencies for dusting ____________ %

Solid and Liquid Disposal Impoundments (Tailings, evaporation, and settling ponds)

Area, volume, capacity of sand tailings ____________ km^2, m^3, MT

Area, volume, capacity of slime tailings ____________ km^2, m^3, MT

Area, volume, capacity of submerged tailings ____________ km^2, m^3, MT

If different grades of ore are used or if a time-dependent scenario is planned, indicate the following for each change:

Area, volume, capacity of sand tailings ____________ km^2, m^3, MT

Area, volume, capacity of slime tailings ____________ km^2, m^3, MT

Area, volume, capacity of submerged tailings ____________ km^2, m^3, MT

Operating time for impoundment area   Attach graph and tables

Fraction of U-238, Th-230, Ra-226, Pb-210 to tailings for each particular ore grade, if applicable ____________ %

Tailings density ____________________ g/cm^3

Drying time prior to reclamation ____________________ yrs

Efficiency of controls for fugitive dusting (wetting, chemical, etc.) ____________________ %

Activity, U, Ra-226, Th-230, and Pb-210 in slimes ____________________ pCi/g

Activity, U, Ra-226, Th-230, and Pb-210 in sand ____________________ pCi/g

Activity, U, Ra-226, Th-230, and Pb-210 in solution ____________________ pCi/l

Total tailings area ____________________ m^2

Tailings pond (solution) area ____________________ m^2

Tailings solids area ____________________ m^2

Tailings impoundment depth ____________________ m

Seepage rate from tailings impoundment ____________________ gpm

Land Use and Grazing of Cattle

Fraction of year spent grazing locally ____________________ %

Fraction of feed that is pasture graze while grazing ____________________ %

Fraction of stored feed that is grown locally ____________________ %

Acreage required to graze one animal unit (450 kg) for one month (AUM) ____________________ ha

Length of growing season ____________________ months/yr

Fraction of local consumption of locally produced:
  vegetables ____________________ %
  meat ____________________ %
  milk ____________________ %

Locations of Sources and Receptors

All locations should be given in terms of:
x kilometers east of the yellowcake dryer stack
y kilometers north of the yellowcake dryer stack
z meters elevation from the base of the yellowcake dryer stack
(Denote locations to the south and/or west by a negative value.)

EXAMPLE:

	Sources	(km) east	(km) north	(m) elevation
1.	Yellowcake dryer	0	0	--
2.	Grinder(s)	--	--	--
3.	Crushers	--	--	--
4.	Rod mill	--	--	--
5.	Ore pad	--	--	--
6.	Fine ore blending	--	--	--
7.	Tailings pond no. 1 (midpoint)	--	--	--
8.	Tailings pond no. 2 (midpoint)	--	--	--
9.	Heap leach pile	--	--	--
10.	Other sources (stacks, vents, etc.)	--	--	--
	Extra Receptors			
1.	Nearest resident	--	--	--
2.	Nearest resident in prevailing wind direction	--	--	--
3.	Ranch	--	--	--
4.	Farm	--	--	--
5.	Orchard	--	--	--
6.	Grazing location 1	--	--	--
7.	Grazing location 2	--	--	--
4.	Garden	--	--	--
5.	Ranger bunk house	--	--	--
6.	Mine camp	--	--	--
7.	Town 1			
8.	Town 2			
9.	City 1			
10.	Other nearby residents (industrial or recreational facilities)	--	--	--
11.	Restricted area boundaries (N, S, E, W, NE, SW, SE, NW)	--	--	--

APPENDIX C

METEOROLOGICAL DATA

Annual Joint Relative Frequency Distributions of Wind Direction and Wind Speed by Atmospheric Stability Class

Wind Direction is given in the 16 compass directions.

Wind Speed is given in knots in the indicated classes:

0-3, 4-6, 7-10, 11-16, 17-21, >21

Atmospheric Stability is given in the following manner:

A - Extremely unstable
B - Moderately unstable
C - Slightly unstable
D - Neutral
E - Moderately stable
F - Very stable

The following table should be prepared for each of these stability classes.

STABILITY CLASS

	Windspeed Class (knots)					
Wind Direction	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	OVER 21
N						
NNE						
NE						
ENE						
E						
ESE						
SE						
SSE						
S						
SSW						
SW						
WSW						
W						
WNW						
NW						
NNW						

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STANDARD FORMAT AND CONTENT OF SITE CHARACTERIZATION REPORTS FOR HIGH-LEVEL-WASTE GEOLOGIC REPOSITORIES

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
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INTRODUCTION

On February 25, 1981, the Nuclear Regulatory Commission (NRC) issued the licensing procedures for the disposal of high-level waste in 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories" (46 FR 13971). As part of the prelicensing procedures set forth in the final rule, the Department of Energy (DOE) is required to submit a site characterization report (SCR) to the NRC as early as possible after commencement of planning for a particular geologic repository operations area and prior to starting site characterization* (paragraph 60.11(a)).** This guide covers, in detail, the many technical and institutional aspects of licensing a high-level waste repository. However, the basic purpose of the SCR is simple: to provide a mechanism for identifying and delimiting the specific issues at a proposed repository site*** and to identify the plans for resolving those issues at an early time in order to avoid delays in the licensing process. The SCR as reflected in the logic sequence and organization of this Standard Format and Content of Site Characterization Reports for High-Level-Waste Geologic Repositories (hereinafter "Standard Format") should accomplish the following:

1. Establish what is known about a site from site exploration activities completed to date,
2. Describe the issues that DOE has identified at a site in light of the results of investigations to date, and
3. Describe the detailed plans to resolve the issues identified.

Objectives of Site Characterization

The site characterization program will include exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions at a site and ranges of parameters that characterize the site.

The objectives of site characterization are:

1. To collect pertinent geological and other site characteristic information that will ultimately be needed for a license application, i.e., sufficient information about DOE's preferred site to support a finding, prior to

---

*As defined in 10 CFR Part 60, site characterization means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under Part 60. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

**On July 8, 1981, NRC published proposed technical criteria, and other conforming provisions, for incorporation into 10 CFR Part 60 (46 FR 35280). The adoption of these provisions as final rules was assumed for purposes of preparing this guide. The guide will be modified, as appropriate, to take into account any changes that may be made in the final technical criteria.

***Site and other terms appearing in this Standard Format have the meanings set forth in proposed § 60.2 of 10 CFR Part 60.

construction, of reasonable assurance that there is no unreasonable risk to public health and safety.

2. To collect necessary data from alternative sites and media to permit the NRC to make National Environmental Policy Act (NEPA) findings with respect to consideration of alternatives.

Objectives of Site Characterization Report

The purpose of the SCR is to generate a document in which DOE:

1. Summarizes (either in the SCR itself or incorporated by reference from an environmental impact statement):

    a. Screening work and criteria that led to selection of the candidate area and site to be characterized,

    b. The decision process by which the site was selected for characterization, and

    c. Plans for screening work and characterization of alternative sites in different geologic media.

2. Describes the site, conceptual design of a repository appropriate to the site, waste form, waste packages, emplacement environment, and performance analysis in sufficient detail so that the site screening and selection process and the planned site characterization program may be understood.

3. Identifies the uncertainties and limitations on site- and design-related information developed during site screening, including issues that need further investigation or for which additional assurance is needed.

4. Describes the detailed programs for additional work to resolve outstanding issues and to reduce uncertainties in the data.

The objective of the SCR is to expedite the licensing process by providing a vehicle for early NRC, State, Indian tribal, and public input on DOE's data-gathering and development work so as to avoid postponing issues to the point where modifications would involve major delays or disruptions in the program. Early review of DOE's site characterization plans, as presented in the SCR, will provide an opportunity for NRC to evaluate whether DOE's proposed program is likely to generate data suitable to support a license application.

Following commencement of site characterization, DOE will provide the NRC Director of the Office of Nuclear Material Safety and Safeguards (NMSS) with semiannual reports (see Appendix A to this Standard Format) that will include the results of site characterization studies, including any new information that might affect the design assumptions concerning waste form and packaging and the planned repository itself. Semiannual reports will also include the identification of new issues, plans for additional studies to resolve these issues, the elimination of planned studies no longer necessary, and the identification of decision points reached and modifications to schedules, where appropriate.

Purpose, Applicability, and Use of This Standard Format

The purpose of this Standard Format is to suggest the types of information to be provided in the SCR in accordance with 10 CFR Part 60 and to establish a uniform format for presenting the information. Use of this format will help ensure the completeness of the information provided, will assist the NRC staff and others in locating the information, and will aid in shortening the time needed for the review process. This Standard Format represents a format that is acceptable to the NRC staff. However, conformance with the Standard Format is not required. SCRs with differing formats will be acceptable if they provide an adequate presentation of the information required by 10 CFR Part 60.

The Standard Format is divided into three parts:

1. Part A provides guidance on the presentation of information related to the criteria used to arrive at the candidate area, the method and decision process by which the site was selected for site characterization, the identification and location of alternative media, and the quality assurance program applied to data collection.

2. Part B provides guidance on the types of information needed to describe the site and the conceptual design (including the waste form and waste package and its emplacement environment) of a repository appropriate to the site. There is no threshold amount of data to be accumulated during the preliminary site exploration activities required prior to the submittal of an SCR. Rather, Part B provides guidance on how to submit information that is currently available.

3. Part C provides guidance on the presentation of the site characterization program, on the identification of unresolved issues, and on the plans to resolve these issues during site characterization.

In its review of Part C, the NRC will look for answers to the following questions:

a. Have the important information needs and unresolved issues been identified?

b. Does the SCR specifically address these information needs and present program plans to obtain the needed information?

c. Are the methods of testing and analysis proposed for the planned site characterization program appropriate?

d. Have alternative methods of testing and analysis been identified and evaluated, and has an adequate basis been provided for the selection of the methods to be used?

e. Will the data to be collected and the reliability of the collection methods and analyses be of adequate quality to support a future construction authorization application?

The SCR will be principally evaluated according to the completeness of Part C, its most critical part.

In developing Part C of the SCR, DOE should ensure that attention is focused on those aspects of siting, development of waste form and packaging, and the conceptual design of a repository appropriate to the site that may require the most effort in the site characterization program. While the SCR must be complete in developing the issues of site characterization, it is important--particularly in initial planning phases--that those issues considered critical or most important to licensing be identified and given highest priority in the site characterization plans.

NRC recognizes that the DOE program of site characterization will be a phased process. NRC expects that data included in the SCR may be better defined and more detailed for early phases of site characterization (e.g., testing in the exploratory shaft) and less detailed for later phases (e.g., testing in an underground facility with two shafts). As DOE completes plans for later phases of site characterization, additional data should be submitted to NRC in semiannual reports (see Appendix A to this Standard Format).

In any event, all site characterization plans for gathering the information needed to conduct the full 10 CFR Part 60 evaluation of site suitability and design acceptability that will accompany the license application should be addressed fully in the SCR for each site.

Supplemental Information

Detailed supplemental information not explicitly identified in this Standard Format may be provided in appendices to the SCR. Examples include:

1. Technical information in support of conceptual design features,
2. Reports furnished by consultants,
3. Summaries of how appropriate NRC regulations and guides were addressed, and
4. Portfolios of maps.

In cases where only representative data (e.g., selected geophysical data from selected borehole logs) are submitted, the original raw data should be accessible either at the site or other appropriate locations and should be readily available to NRC. Representative data should be of sufficient quality and quantity to permit an understanding of the nature and extent of the set of data actually available.

Style and Composition

Information should be presented clearly and concisely. Claims of adequacy of designs or design methods should be supported with technical bases.

Units of measurement (both fundamental and derived) should be given in the International System of Units (SI). If common industrial usage is in other units and the use of SI would be confusing, give the measurement in accepted units with SI units in parentheses.

The SCR should follow the numbering system and headings of the Standard Format at least down to the headings with three digits, e.g., 3.3.2 Tectonic History.

Avoid duplication of information. Similar or identical information may be requested in various sections of the Standard Format because it is appropriate to more than one portion of the SCR. In such cases, present the information in the principal section, and reference it appropriately in the other applicable sections.

Where numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. Where appropriate, estimated limits of error or uncertainty should be provided.

Abbreviations should be consistent with generally accepted usage throughout the SCR. Any abbreviations, symbols, or special terms not in general use should be defined when they first appear in the SCR.

Graphic presentations such as drawings, maps, diagrams, sketches, and charts should be used where the information can be presented more adequately or conveniently by such means or when the interpretation of data can be clarified. All information presented in drawings should be legible, symbols defined, and drawings not reduced to the extent that visual aids are necessary to easily interpret pertinent items of information presented in the drawings. When a series of maps is submitted, a common scale should be used whenever possible.

Bibliography

Bibliographic listings of documents or reports discussed in the SCR should appear at the end of the chapter in which they are first mentioned. For each report or document (e.g., articles in professional journals) listed in the bibliography, include the author, the title, the report or document number, and the date of publication and/or of submittal to NRC. For any reports that have been withheld from public disclosure as proprietary documents, nonproprietary summary descriptions of the general content of such reports should also be included in the bibliography. In cases where proprietary documents were used to obtain information, provide a nonproprietary summary of the document. Bibliographic listings may include not only documents and reports but also data on file at the site or project office (e.g., drill logs, hydrologic test data).

Physical Specifications

1. Paper Size

Text pages: 8-1/2 x 11 inches.

Drawings and graphics: 8-1/2 x 11 inches preferred; however, a larger size is acceptable provided the bound side does not exceed 11 inches, except where required for legibility, and the finished copy when folded does not exceed 8-1/2 x 11 inches.

2. Paper Stock and Ink

Suitable quality in substance, paper color, and ink density for handling and reproduction by microfilming or image-copying equipment.

3. Page Margins

A margin of no less than 1 inch should be maintained on the top, bottom, and binding side of all pages.

4. Printing

Composition: should be single-spaced text pages.

Type font and style: must be suitable for microfilming.

Reproduction: may be mechanically or photographically reproduced. Text pages should preferably be printed on two sides with the image printed head to head.

5. Binding

Pages should be punched for standard 3-hole loose-leaf binder.

6. Page Numbering

Pages should be numbered with the two digits corresponding to the chapter and first-level section numbers followed by a hyphen and a sequential number within the section, i.e., the third page in Section 4.1 of Chapter 4 should be numbered 4.1-3. Do not number the entire report sequentially. (Note that, because of the small number of pages in many chapters, this Standard Format is numbered sequentially throughout the document.)

PART A

STANDARD FORMAT AND CONTENT GUIDANCE FOR DESCRIBING THE CRITERIA AND DECISION PROCESS OF SELECTING CANDIDATE AREAS AND SITES

Part A of the Standard Format is designed to provide guidance on the following issues, as set forth in paragraph 60.11(a):

1. The types of information needed to evaluate the criteria used to arrive at the candidate area;
2. The method by which the site was selected for site characterization;
3. The identification and location of alternative media and sites at which DOE intends to conduct site characterization and for which DOE anticipates submitting subsequent SCRs;
4. A description of the decision process by which the site was selected for characterization; and
5. A description of the quality assurance program to be applied to data collection.

1. PROGRAM OVERVIEW

1.1 National Waste Terminal Storage Program

Briefly summarize how the site chosen for site characterization fits into the national waste terminal storage program for identifying alternative sites in different rock types.

1.2 Identification of Agents and Contractors

Identify the DOE project management organization. Describe the DOE technical projects and tasks. Prime agents or contractors for site investigations, design, waste form and packaging, and performance analysis should also be identified. All principal consultants, outside service organizations, and key research groups to be involved with site characterization should be listed. The division of responsibility and lines of communication among these various parties should be delineated.

1.3 Quality Assurance

Describe the quality assurance (QA) programs that have been applied during site exploration activities and that will be applied to data collection during the planned site characterization program. The QA methods should be presented in sufficient detail to allow NRC to make an independent evaluation of the precision, accuracy, reproducibility, analytic sensitivity, and limitation of data acquisition and analysis methods that were used during site exploration and will be used during site characterization.

2. DECISION PROCESS FOR CHOOSING CANDIDATE AREA AND SITE

This chapter should describe the decision process through which a particular site was selected for site characterization. This description should define the criteria used to arrive at the selection of the candidate area, the method by which the site was selected for characterization, the identification of alternative sites, and a description of the decision mechanism used to evaluate the technical, environmental, legal, and institutional criteria.*

2.1 Technical Factors

In accordance with 10 CFR Part 60, discuss the application of the following types of technical criteria used in screening and selecting the site.

1. Geological,
2. Hydrological,
3. Meteorological,
4. Geochemical,
5. Geomechanical,
6. Geophysical,
7. Resource evaluation,
8. Human activity, and
9. Any other pertinent factors that affected the site selection process.

2.2 Environmental Factors

Describe how the following environmental factors influenced site selection.

1. Radiological,
2. Ecological,
3. Air quality,
4. Water quality,
5. Land resources and use,
6. Esthetics,
7. Historical, archeological, and cultural resources, and
8. Socioeconomics.

2.3 Legal and Institutional Factors

2.3.1 State, Indian Tribal, and Local Laws

Discuss the extent to which State, Indian tribal, and local laws and regulations have entered into the site selection process, including any specific State constitutional provisions, laws, regulations, or local ordinances that are relevant to site selection.

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*To the extent that the information described in this chapter appears in an environmental impact statement prepared by DOE for site characterization at the named site, it may be incorporated into the SCR by reference.

2.3.2 Federal Legal Framework

To the extent that other Federal agencies have statutory responsibilities affecting repository site selection, discuss how these responsibilities have entered into the site selection process. Also, discuss any other Federal statutes, treaties, and administrative regulations that affect site selection.

2.3.3 Land Ownership

Discuss the manner in which land ownership and the ability to acquire jurisdiction and control affect site selection.

2.3.4 Public Involvement

2.3.4.1 State, Indian Tribal, and Local Government Participation in the Decisionmaking Process. Identify the government units affected by the proposed site, the methods used to accommodate their viewpoints, and the provisions made for their continuing involvement in the site selection process.

2.3.4.2 Public Participation. Identify the provisions made for public input into the site selection process, the nature of public involvement, and how public attitudes affected the site selection process.

2.4 Identification of Alternative Sites

Identify and describe all other sites and media for which DOE is conducting, or intends to conduct, site characterization. Indicate the current status of the site investigations, an outline of planned activity, and actual or estimated submittal dates for the SCRs.

2.5 Decisionmaking Analysis

For the selected candidate area and site, describe the method by which the site was evaluated against the criteria in Sections 2.1, 2.2, and 2.3. Include a discussion of any quantitative methods used, problems associated with the availability and reliability of data, any value judgments made, and an explicit identification of the tradeoffs made among the various criteria.

If the results of performance assessment were used in the decision process to (1) screen sites or (2) choose the site for the characterization program, these results, as well as the performance assessment techniques (including simplifying assumptions and boundary conditions) should be discussed. The discussion of the performance assessment should be presented in sufficient detail to permit an independent evaluation. In the discussion of the performance assessment, specific sections of other documents (e.g., user manuals and code documentations) may be incorporated by reference, provided these documents are either publicly available or, if proprietary, are readily available to NRC.

PART B

STANDARD FORMAT AND CONTENT GUIDANCE FOR DESCRIBING THE SITE, WASTE FORM AND PACKAGE, AND CONCEPTUAL DESIGN OF A REPOSITORY

Part B of the Standard Format is designed to provide guidance on the types of information needed to describe the site to be characterized (paragraph 60.11(a)(1)). The main purpose of describing the site and conceptual design of a repository appropriate to the site (including a description of the waste form and waste packaging and environment) will be to provide information to support the site screening and site selection process, provide information to allow issues to be identified, and provide information to support the site characterization program for resolving the issues. The descriptions should include the method of investigation used to obtain the information, the methods of evaluation used, and the limitations and uncertainties of either the method of investigation or the data used in the evaluation.

The NRC recognizes that, because of the generic nature of this Standard Format, some of the information requested in Chapters 3-8 (e.g., volcanic history) may not be appropriate to specific sites. The NRC also recognizes that the level of detail requested in some sections of Chapters 3-8 may not be available at the time the SCR for a particular site is submitted.

3. GEOLOGIC DESCRIPTION OF CANDIDATE AREA AND SITE

A description of the geology of the candidate area and site should be provided in this chapter. This information is needed to understand the selection of the site for characterization, the relationship of the conceptual design of a repository appropriate to the specific site, and the rationale for the proposed site characterization program.

Where geophysical techniques such as gravity, heat flow, and magnetic surveys have been conducted in support of geologic studies (e.g., subsurface stratigraphy or structure), this fact should be noted in the appropriate sections of this chapter. When geologic information has been obtained from the literature, the sources should be referenced.

3.1 Geomorphology

Describe the physiography, topography, geomorphic units, and geomorphic processes for the candidate area and site. Discuss the application of geomorphology to site screening and selection for characterization.

3.1.1 Physiography and Topography

Describe the physiographic province(s) in which the candidate area and site are located. This should include the description province name(s), areal extent, relationships to surrounding province(s), distinguishing characteristics (e.g., elevation, relief), and major active processes modifying the present-day topography. This information should be provided by means of topographic maps of the candidate area and site using appropriate scales and contour intervals needed to support other studies associated with this site. When available, representative ground-level photographs, vertical and oblique aerial photographs, and satellite imagery should be included. Sources of information used to obtain the above descriptions should be listed.

3.1.2 Geomorphic Units

Describe each geomorphic unit by giving its name, areal extent, distinguishing characteristics, and other pertinent information. All units should be shown on a topographic map. Geomorphic units should be defined using a combination of factors influencing geomorphic processes such as near-surface geology and soil, relief, landform morphology, and biota.

3.1.3 Geomorphic Processes

Describe any geomorphic process that could affect the ability of the site to isolate radioactive waste. Each process should be discussed from the perspective of past, present, and estimated future activity. Emphasis should be placed on present and Quaternary processes since these may be the most useful for estimating future activity. However, information on older processes should also be given where it is useful for understanding present ground-water systems or predicting future changes (e.g., salt dissolution or collapse breccias) or where it can contribute to estimating the potential occurrence of future processes.

Each geomorphic process should be described, including (1) rate of activity, (2) frequency of occurrence and cycles, and (3) controlling mechanisms or factors.

3.2 Stratigraphy

Using available information, describe the stratigraphic framework of the candidate area and site, including both surface and subsurface geology. Distinguish between Quaternary and pre-Quaternary stratigraphic units.

Descriptions and illustrations (e.g., maps, columns, cross sections) should be given in sufficient detail, legibility, style, and quality to permit their evaluation by independent reviewers.

Uncertainties associated with stratigraphic extrapolations should be discussed.

3.2.1 Surface Geology

Provide a map of the surface geology and, where the information is available, relate surface rock units to those in the subsurface. Where feasible, nationally recognized geologic symbols should be used.*

3.2.2 Stratigraphic Framework of Candidate Area

Provide a framework for the stratigraphy of the candidate area in the following manner:

1. Present a map of the candidate area. State the technical bases (e.g., sedimentary basin) for the boundary of the candidate area, and include all areas relevant to studies supported by stratigraphy.

2. Illustrate the stratigraphy and lithology of the candidate area using such materials as geologic maps, representative lithostratigraphic columns, and cross sections. Lithostratigraphic sequences should be characterized in three dimensions in sufficient detail to give clear orientation and order to the detailed descriptions of rock units in the candidate area. For each lithostratigraphic sequence, list major unconformities, the age, range of thickness, spatial extent, major rock units, and vertical and lateral variations. Present an overall geologic time sequence (periods, epochs, and ages) for the rock units of the candidate area.

3. Present a genetic model for the origins and development of the rock sequences that includes a general geologic history through time of the rock sequence and the processes that formed and altered the sequence. Include subjects such as sedimentary tectonics, source area, depositional and diagenetic environments, volcanism, plutonism, and metamorphism.

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*See Data Sheet Numbers 1-4, American Geological Institute, 5205 Leesburg Pike, Falls Church, Virginia 22041.

3.2.3 Stratigraphic Framework of Site

Describe the stratigraphy of the site, using surface and subsurface information when available. This information can be obtained from the literature or from the results of preliminary site exploration activities. Provide representative photographs and geophysical logs for the lithostratigraphic units when available. For wells that have been cored, representative driller logs, lithologic and geophysical logs, and core photographs should be provided.

Lithostratigraphic units can be formal (groups, formations, or members) or informal (sequences or lithofacies) and should represent the degree of subdivision of the rock mass necessary to permit an evaluation of the planned site characterization program.

Each lithostratigraphic unit should be described.* Descriptions should include but not be limited to:

1. The name, using established nomenclature,

2. Lithologic and mineralogic composition,

3. Diagnostic physical and paleontological characteristics useful for identification and correlation (e.g., color, sedimentary structures, texture, fabric, trace elements content, fossil content),

4. Physical characteristics significant to isolation of radioactive waste such as bedding, mineralogy, grain size, intergranular fillings, cement, and secondary mineralization,

5. Geophysical characteristics or signatures (surface and subsurface, including downhole),

6. Vertical and lateral variation of composition and characteristics and comparison to surrounding units (lithofacies maps),

7. Thickness and spatial extent (isopach maps, geologic columns, cross sections, fence or block diagrams),

8. Structure (specific attitude measurements or inferred structure from geophysical data) and its variation (reference other sections of the SCR as needed for detail),

9. Vertical and lateral relationships to surrounding rock units (contacts and unconformities),

10. Age, and

11. Genesis or origin of the unit, including rock formation processes and models (deposition, intrusion, extrusion) and rock alteration processes and models (metamorphism and diagenesis).

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*See "Code of Stratigraphic Nomenclature," in the Bulletin of the American Association of Petroleum Geologists, Vol. 45, pp 645-665, 1961, and subsequent revisions.

3.3 Structural Geology and Tectonics of Candidate Area and Site

Define the tectonic elements of the candidate area and site, and describe any pre-Quaternary and Quaternary structures present. If known, structural features that may create pathways from the depths of the conceptual design of a repository appropriate to the site to the accessible environment* should be described regardless of age. Structural features that provide information about the tectonic stability of the site should be described. In addition, structural features occurring in active areas of strain release that have constituted major tectonic boundaries in their geologic history or that may be reactivated to create tectonic instability should also be described.

3.3.1 Tectonic Framework

Discuss the tectonic framework of the candidate area and site. Identify those tectonic processes that have been active since the start of the Quaternary. Maps and cross sections that show all major tectonic features, including crystalline shields, sedimentary basins, uplifts, orogenic and fold belts, volcanics, major faults, and major joint sets, should be provided when available.

3.3.2 Tectonic History

Describe the tectonic history of the candidate area and site from the earliest recognizable tectonic elements through the end of the Pliocene. The tectonic history should include the age and sequence of development of all major crystalline shields, sedimentary basins, uplifts, orogenic and fold belts, volcanics, major faults, and major joint sets.

3.3.2.1 Volcanic History. The volcanic history should be described when applicable to a particular site or candidate area. Maps of the candidate area and site showing the distribution of extrusive and intrusive rocks should be provided.

If there is more than one period of volcanic activity in the candidate area or if there has been repeated volcanism during the Quaternary, a table listing the volcanic episodes should be included. The table should describe the type of extrusive or intrusive rock, composition of the volcanics, age, geometric relationship to other volcanics, and the stratigraphy of the surrounding rocks. A description of each major period of volcanism should be presented for each volcanic episode listed on the table.

The mineralogy and geochemistry of each volcanic unit should be presented in this section and referenced in other appropriate chapters of the SCR. Alteration, contact metamorphism, and mineralization of country rocks surrounding the flows should be discussed as well as any weathering and alteration of the volcanic rocks themselves. Fracturing and faulting associated with volcanism, including attitude, spacing and size of fractures, and cross-cutting relationships among fractures in country and volcanic rocks, should be described.

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*For a definition of the term accessible environment, refer to proposed § 60.2 of 10 CFR Part 60.

The effects of the volcanism on the interstitial and secondary porosity and permeabilities of the country rocks and the effect of volcanism on the regional hydrogeology should be described. If this information is not currently available, present plans in Part C for obtaining it during site characterization.

Based on the Quaternary volcanic history, predict the potential for future volcanic activity in the candidate area with emphasis on the next 10,000 years.

3.3.2.2 Faulting History. The faulting history of the candidate area and site should be described. The description should include the distribution, characteristics, attitude, spacing, length, strike direction, dip of the fault plane, and width and nature of the fault zone of the faults. This should be accompanied by a map showing the location, strike, and dip of all known and suspected faults. The extent to which faults may act as pathways to the accessible environment from the conceptual design of a repository appropriate to the site should be estimated if possible.

Provide information on surface offsets and net slip of all the Quaternary faults and the amount of basement offset associated with each fault. All assumptions for determining true offset should be explicitly stated. The movement history, including rate of displacement and recurrence interval, should be identified. Absolute and relative dating techniques should be applied where possible. If more than one period of Quaternary faulting is present within the candidate area or site, the fault systems of different ages should be tabulated, and the evidence for the age of each fault should be presented.

3.3.2.3 Folding History. The folding history of the candidate area and site should be discussed, and a map that shows the location and trend of fold belts in the candidate area should be included.

Describe the geometry, symmetry, wavelength and amplitude of the folds, their mode of origin (e.g., flexural slip), and their attitude relative to the earth's surface (upright, inclined, overturned, or recumbent). The trend and plunge of the fold axis and the strike and dip of the axial surface of each major fold, along with its sense of asymmetry, should be mapped. Cleavage, fractures, and faults associated and penecontemporaneous with the folding should be delineated from available information. Any change in porosity and permeability of the rocks due to folding should be discussed.

Describe the overall nature of the folding. "Thin-skinned" tectonics should be distinguished from "thick-skinned" or basement tectonics.

If more than one period of folding is present, the evidence that allows the relative and/or absolute dating of the individual episodes of folding should be included.

3.3.2.4 Jointing History. The jointing history of the candidate area and site should be described as thoroughly as possible. A map showing the location and trend of all known joint sets should be included. For each joint set, the areal distribution, the attitude, and the intensity of jointing (i.e., joint spacing) within the candidate area and site should be presented. Absolute or relative dating of the joint sets should be provided when known.

The mineralogy and age of fillings along joints of any age should be discussed. The possibility that joints may form pathways from the depth of a conceptual design of a repository appropriate to the site to the accessible environment should be discussed. The effect of various joint sets on the fracture permeability of the rock should be provided, or the appropriate sections of Chapter 5, "Hydrology," should be referenced. The relationship of joints to the regional faulting and folding should be described.

The mode of origin of the joints (i.e., extension or shear mechanism) should be discussed. If microcracks are present, describe their geometric and genetic relationships to systematic and nonsystematic joints.

A table listing the various joint sets, in order of age along with their principal characteristics, should be included.

3.3.2.5 Uplift, Tilting, and Subsidence. Uplift, tilting, and subsidence in the candidate area and site, including effects caused by withdrawing or injecting fluids and mining, should be discussed when applicable. This discussion should include the suspected causes of uplift, tilting, and subsidence as well as the rate, magnitude, and areal extent of the uplift, tilting, and subsidence. Quaternary deformation not classified as folds, faults, or joints, e.g., features related to salt tectonics, should also be described.

3.3.2.6 Active Stress Field. The active stress field in the candidate area and site should be discussed. All in situ stress measurements that have been done within the candidate area should be summarized. The data should be tabulated to show the method of stress measurement (e.g., overcoring, the flat jack method), the depth of the measurement, and the actual magnitude and orientation of the principal stresses.

3.3.2.7 Vertical Crustal Movement. Existing data on crustal movements should be summarized and tabulated. Time-dependent gravity and geodetic surveys and geomorphic analyses of landforms should be summarized.

3.4 Seismicity of Candidate Area and Site

The seismic information presented in this section should provide a description of the available seismic data and their relationship to the geologic and tectonic conditions of the candidate area and site. The rationale for using any seismic parameters as bases for any portion of the conceptual design of a repository appropriate to the site should be explained. Information needs for which sufficient data are not currently available should be identified, and plans to obtain the information should be set forth in Part C of the SCR.

3.4.1 Seismicity of Candidate Area

Provide a description of the seismic history of the candidate area. Relate historic earthquakes to seismic and tectonic zones. Whenever it is available, the following information should be provided: hypocentral coordinates, origin time, magnitude, total dislocation, focal mechanism, and error estimates for these data. Present a regional scale map of all the listed earthquake epicenters.

Identify the technique used to locate all hypocenters and to determine magnitudes. Differentiate earthquakes on the basis of focal depth, where applicable.

Whenever applicable, define the precise locations of hypocenters of small earthquakes, and use these locations to map zones where relief of crustal stress is occurring. Identify seismic conditions that influenced the conceptual design of a repository appropriate to the site.

Provide a listing of all known historic earthquakes of magnitude greater than 3 or MM intensity greater than IV that have been reported for the candidate area. When information is available, estimates of intervals of recurrence, maximum probable and credible earthquake magnitudes for the candidate area, and how these estimates were derived should also be discussed.

The probability of future major earthquakes within the candidate area should be discussed. Available information on focal mechanisms should be evaluated with respect to tectonics and stress distribution. Information needs for which sufficient data are not currently available should be identified. Plans for obtaining this information should be included in Part C of the SCR.

When earthquakes are located on the basis of arrival times of seismic waves, the particular seismic waves should be identified. The local seismic-velocity model used for interpreting and refining travel-time data should be documented.

Revised locations of earthquake epicenters or hypocenters that differ substantially from original locations should be noted. Whenever a revised location is adopted in place of an original location, an explanation for the preference should accompany the revised location. Focal mechanisms that differ significantly from the majority derived for the region should be specifically noted.

3.4.2 Seismicity of Site

The seismicity of the proposed site should be described. The relationship between the seismicity of the proposed site and geologic features should be discussed. Information needs for which sufficient data are not currently available should be identified. If applicable, plans for seismic studies and monitoring programs should be described in Part C of the SCR.

3.5 Long-Term Regional Stability with Respect to Tectonic and Geological Processes

Based on Quaternary and present-day active tectonic, geophysical, and geological processes, an assessment of the future stability of the candidate area should be presented with emphasis on the next 10,000 years. Pre-Quaternary structures located within active stress fields should also be assessed. All models, assumptions, parameters, and sensitivity tests to be used for making these assessments should be explicitly stated.

3.6 Subsurface Drilling and Mining

Comprehensive information pertaining to past and present drilling and mining operations should be presented for the candidate area and site. This should include a tabulation of all active and abandoned wells, boreholes, and excavations at the candidate area distinguishing between those wells, boreholes, and excavations that preceded site exploration and those that were part of site exploration. The tabulation should also include such information as the location, depth, diameter, drilling method, casing left in the hole, and method of plugging or sealing. The methods used to investigate the extent of previous drilling and excavation should be discussed. A map showing the location of active and abandoned wells, boreholes, and excavations and the plan view of the conceptual design of a repository appropriate to the site should be provided. If the information is available, describe the former use of previous boreholes and the types of testing that were conducted in them. Copies of representative data, logs, and interpretations should be included. Documentation related to calibration procedures and data-massaging techniques should be provided. Interpretation of results should be supported with adequate references. Discuss the adequacy of the historical record in determining the likelihood of undiscovered wells, boreholes, and excavations in the volume of rock and their possible effects on the site. Also include any known boreholes that were lost because of cave-ins or equipment failures.

Provide available information on the effects of the active and abandoned wells, boreholes, and excavations on the principal hydrogeologic units. If sufficient information is available, the presence of potential pathways should be indicated and the net flux and hydraulic gradients created by them should be assessed. (If the information in this paragraph is included in the discussion of hydrology, the appropriate sections of Chapter 5, "Hydrology," may be referenced.)

Provide descriptions, plans, and sections of all active or inactive underground mines within the candidate area, including both conventional mines and in situ extraction types of operations whenever applicable. Describe the kinds of minerals extracted, methods of mineral extraction, the volume of rock removed, and the volume of rock replaced. Include a statement of the present condition of the workings as to subsidence, stability, and flooding.

3.7 Mineral and Hydrocarbon Resources

Information pertaining to the mineral and hydrocarbon resources of the candidate area and site should be presented in this section.

3.7.1 Mineral Resources

To the extent that information on the mineral resources is available prior to site characterization, the following information should be provided.

The resources of the site should be compared with the resources in comparable areas (those of similar size and geology). Total resources, both identified and undiscovered as defined in the U.S. Geological Survey Bulletin 1450a,* should be included.

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*"Principles of the Mineral Classification System of the U.S. Bureau of Mines and the U.S. Geological Survey," U.S.G.S. Bulletin 1450a, 1976.

Provide a tabulation of the total resources, including (1) the quantity of resources, (2) the cutoff values used in estimating (1), (3) the present gross value of each substance, (4) the present net value of each substance, i.e., the gross value less the costs for exploring, developing, extracting, and marketing the substance, and (5) the unit values of the minerals evaluated in (3) and (4). For each substance, describe the method of assessment.

3.7.2 Hydrocarbon Resources

Describe and locate any past or present oil and gas wells in the candidate area. Discuss the likelihood of future development in the candidate area, including both reserves and potential resources.

4. GEOENGINEERING

In this chapter the mechanical, thermal, and thermomechanical properties of the rock units and the expected mechanical boundary conditions that are the basis for the conceptual design of the geologic repository should be presented. Each discussion should include a brief summary of generic information from similar rock units and projects and site-specific information,* if available. The information should be in sufficient detail to (1) permit an understanding of the geomechanical basis of the proposed conceptual design of a repository appropriate to the site (Chapter 8), and (2) support the discussion of design issues in Part C. The discussions should include values or ranges of values for the design parameters used in the conceptual design and should provide the rationale for selecting these preliminary values.

For each of the properties of the rock units, include a discussion of the equipment and procedures used, including their limitations and the errors produced by them. (Equipment and procedures should be referenced to the appropriate standards, e.g., ASTM, where available.) Geologic borehole logs, geologic cross sections, or photographs accumulated during preliminary site exploration activities should be provided when possible to show where tests were conducted or samples were taken. Any measures taken to preserve or restore the in situ chemical and physical environment during site exploration should be described. The anisotropy of the properties should be addressed. If isotropic approximations are assumed, justify that assumption.

4.1 Mechanical Properties of Rock Units - Continua

Present the mechanical properties of the rock units as determined by laboratory tests on samples of the potential host rock and of other rock units important for the conceptual design of a repository appropriate to the site and its performance if available. Also present available generic data from similar rock units. Include site-specific information, when available, on elastic and inelastic behavior, compressive and tensile strength, and effects of heating and fluid pressure on these properties.

4.2 Mechanical Properties of Rock Units - Large Scale

Present the results of any large-scale laboratory and field tests such as plate-bearing tests, hydrostatic test chambers, flat jacks, Goodman jacks, and convergence tests. ("Large-scale" here means tests of sufficient size to take into account the discontinua (fractures, joints, inhomogeneities, etc.) of the media.) Discuss the relationship of the results of the laboratory tests to the results of the large-scale tests. Provide site-specific data, if available, as well as available generic data for similar rock units and environments.

4.3 Mechanical Properties of Rock Units - Discontinua

Describe the mechanical properties of discontinua (fractures, joints, bedding planes, inclusions, voids) present in the rock units. Provide site-specific data as well as available generic data from similar rock units and environments. If the information is available, the discussion should include the coefficient of friction, the compressibility of fractures and filling materials, and the effect of heating and changes of pore pressure on the mechanical properties of the joints, fractures, bedding planes, and other discontinua. Discuss the effects of the discontinua on the mechanical properties of the rock mass (e.g., strength and deformation characteristics).

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*Site-specific information means information gained from tests done in, or samples taken from, limited borings, surface outcrops, near-surface test facilities, pre-existing tunnels or mines, etc., near the site proposed for characterization. It does not imply that a shaft has been sunk.

4.4 Thermal and Thermomechanical Properties - Laboratory Results

Present the results of laboratory studies of the thermal properties of the rock units. Provide available site-specific data as well as generic data from similar rock units.

Include discussions on the thermal conductivity, heat capacity, and coefficient of thermal expansion of the rock units.

4.5 Stress Field

Present the stress field data, if available, and list the assumptions used to infer stress from field observation. Also present applicable stress measurements that have been made in the candidate area or at the site. Include a discussion of the expected direction and magnitude of the principal stresses as a function of depth.

4.6 Special Geoengineering Properties

Describe any special thermal, mechanical, thermomechanical, or other properties of the rock units that were considered in developing the conceptual design of a repository appropriate to the site (e.g., brine migration, thermal decrepitation, thermal dewatering). Provide available site-specific data as well as generic data from similar rock units.

4.7 Excavation Characteristics of Rock Mass

Describe excavation investigations that have been conducted within the candidate area, and discuss pertinent excavation experience in similar rock type under similar conditions using various techniques such as controlled blasting and mechanical nonblasting. This discussion should include information on how the investigations were monitored, analyzed, and applied to the conceptual design of a repository appropriate to the site. The discussion should also include an assessment of the potential damages produced by the various techniques and appropriate methods for avoiding or mitigating such damages.

5. HYDROLOGY

Include in this chapter pertinent information gathered on hydrologic conditions of the candidate area and site. Surface and subsurface hydrologic regimes should be addressed. The information should be presented in sufficient detail to (1) describe the hydrology based on available literature and preliminary site exploration activities and (2) provide information to be used to analyze the hydrologic aspects of the planned site characterization program.

Include, as applicable, data sources and estimated uncertainties. Discuss any significant consequences of the uncertainties about conclusions drawn from the data.

5.1 Description of Surface Hydrology

Describe the hydrologic framework of the surface waters of the candidate area and site. Address the location and physical and hydrologic characteristics of surface-water bodies such as streams, lakes, and shore regions influencing the site. Include a description of existing and proposed water control structures, both upstream and downstream, that may influence conditions at the site.

5.2 Floods

5.2.1 Flood History

Provide the date, level, peak discharge, and related information for major historical flood* events in the candidate area. Include stream floods, surges, seiches, tsunami, dam failures, ice jams, floods induced by landslides, and similar events.

Discuss whether the site is flood dry or non-flood dry using procedures presented in ANSI N170-1976.** If procedures other than those presented in ANSI N170-1976 are used, state the reasons and describe the procedures.

Discuss the potential for future flooding of the site. Include long-term changes in the hydrometeorology of the region and the potential for floods induced by maximum glaciation. Describe planned or ongoing studies to thoroughly investigate the potential for future flooding. Include geologic evidence of Pleistocene and Holocene flooding in the assessment of future flood potential.

5.2.2 Flooding Protection

Describe the static and dynamic consequences of all types of flooding that could occur at the candidate area and site. Present the plans and any completed flow analyses needed to ensure that these types of flooding would allow continued integrity of surface and subsurface structures at the site.

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*A flood is defined as any abnormally high water stage or overflow from a stream, floodway, lake, or coastal area that results in significantly detrimental effects.

**See American National Standards Institute (ANSI) Standard N170-1976, "Standards for Determining Design Basis Flooding at Power Reactor Sites." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

5.3 Locations and Distances to Points of Surface-Water Use

5.3.1 Present Quantity and Quality of Surface Water Extracted

Provide a tabulation of existing surface-water intakes (including collector well systems) downstream of any identified ground-water discharge areas. For each surface-water intake, provide the location, population served, type of intake, and the maximum daily and average quantities of water pumped. Also, the water quality at the intake locations and the type of treatment given to the water before distribution should be discussed.

5.3.2 Projected Surface-Water Uses

Estimate quantities and potential areas of water use for the region for 50 and 100 years into the future. Base the projections on expected growth rate of the region; industries likely to develop in the future because of location, climate, or natural resources; and probable changes in the technology or economic requirements. Do not base the projections on extrapolations of historical data alone. Also locate possible points of withdrawal for any potential future water users that have been identified.

5.4 Chemical, Biological, and Ecological Composition of Adjacent Watercourses

Describe the chemical, biological, and ecological composition of adjacent bodies of water that could potentially be affected by releases from the facility. The chemical data should be sufficient to determine the salt seep or salt discharge rates into drainage basins for dissolution studies. This description should include measured baseline data derived from historical records and onsite monitoring programs prior to site characterization activities.

Identify, to the extent possible, the source and nature of the background pollutants (e.g., chemical species and physical characteristics such as color and temperature), the range of concentrations involved, and the time variation in release. Information relating to water quality characteristics should include measurements made on, or in close proximity to, the site.

The seasonal cycles of physical and chemical limnological parameters should be provided. Additionally, information that describes the bottom and shoreline configuration, sedimentation rates (suspended and bed load), sedimentation graduation analysis, and distribution (sorption) coefficients should be included.

5.5 Surface-Water/Ground-Water Disposition of Releases

Identify, define, and map all known sources of ground-water discharge within the candidate area, including springs, seeps, and wells. Provide an estimate of the rate of ground-water discharge at these points. If the discharge is through a stream channel or lake bed, the discharge per square meter of lake bed or linear meter of stream channel should be estimated. Provide the bases for the discharge estimates such as base flow measurements, water balance calculations, and aquifer hydraulics.

Discuss the potential for contamination of surface waters as a result of either surface or subterranean releases. Any surface discharge areas (springs and seeps) of aquifers that could become contaminated by releases from the subsurface operations during site characterization should be identified.

5.6 Regional Hydrologic Reconnaissance of Candidate Area and Site

Describe the regional hydrogeologic framework and regional ground-water flow systems and their boundaries.*

5.6.1 Hydrogeologic Units

Present a hydrogeologic column of the region in a form as detailed as the information allows. Include the principal hydrogeologic units (includes both confining units and aquifers), their stratigraphic relationships, lithology, generalized potentiometric levels for a given time and location, and hydrologic characteristics. The terminology should be consistent with the terminology used in the regional stratigraphic column presented in Section 3.2. A hydrogeologic map of the candidate area should be presented indicating areal extent of the regional hydrogeologic units and unit interfaces.** Cross sections should be provided where appropriate.

5.6.2 Relationships Among Hydrogeologic Units

Describe the relationships among the regional hydrogeologic units. The principal relationships sought are potentiometric levels, recharge-discharge and leakage, hydrochemical facies, and ground-water residence times. References should be made to the hydrogeologic map and to the cross sections presented in Section 5.6.1.

5.6.3 Potentiometric Level

Define the time history and areal distribution of measured potentiometric levels of each principal hydrogeologic unit. The method of presenting the data can include hydrographs, potentiometric contour maps, and graphs to identify the characteristic fluctuations resulting from the various types of recharge-discharge (i.e., seasonal precipitation and evaporation fluctuations, seasonal pumping variations, seasonal response to surface-water bodies, etc.). Potentiometric surface maps should include such information as the location of the monitoring wells, hydrogeologic unit boundaries, surface-water bodies, and specific well information (i.e., perforation interval and elevations, total depth history, casing, method of well completion, etc.).

5.6.4 Hydraulic Characteristics of Principal Hydrogeologic Units

For each of the principal hydrogeologic units, provide the ranges, mean values, and methods for determining the principal hydraulic characteristics such as hydraulic conductivity, storage coefficient, effective porosity, and saturated thickness. Also include a discussion of the appropriateness of assuming Darcian flow conditions in the various hydrogeologic units.

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*Definitions of ground-water terminology used in this chapter are consistent with U.S. Geological Survey Water Supply Paper No. 1988, Definitions of Selected Ground-Water Terms - Revisions and Conceptual Refinements (1972).

**Use, where practicable, internationally recognized map symbols (UNESCO, International Legend for Hydrologic Maps, Paris, France, 1970, 101 p.).

5.7 Regional Ground-Water Flow System

Provide detailed information on the regional ground-water flow system, including identification of recharge and discharge areas, principal ground-water flow paths, and ground-water ages based on isotopic hydrochemistry.

5.7.1 Identification of Recharge-Discharge Areas

Identify the areas and modes of recharge and discharge, residence times of the ground water, and the bulk rates of ground-water flow for the specific hydrogeologic units. Also include surface- and ground-water interrelationships. Present the information on hydrogeologic maps developed for the region.

5.7.2 Principal Ground-Water Flow Paths

Describe the principal ground-water flow paths with the associated fluxes and travel times to the accessible environment if known. Use cross sections and maps to indicate the principal ground-water flow paths.

5.7.3 Isotopic and Regional Hydrochemistry

Describe the results of any investigations of the isotopic composition of ground-water samples. Include stable isotopes, e.g., D/H, O^{16}/O^{18}, and unstable isotopes, e.g., C^{14}, H^3, Cl^{36}. Discuss the implication of the isotopic data concerning the age of the ground water, relative degree of circulation within the hydrogeologic unit, and areas and modes of recharge to the hydrogeologic units.

Describe the results of any studies of the regional hydrochemical zones. The major ions of interest are Na^{+}, Ca^{+}, Mg^{+}, Cl^{-}, Fe, Mn^{++}, HCO_3^{-}, CO_3^{2-}, and SO_4^{2-}. The individual hydrochemical zones should be presented in graphic form showing the relationship among the principal ions. Each zone should also be delimited by its pH, Eh, total dissolved solids (TDS), organic carbon, organic complexes (fulvic and humic acids), and aforementioned principal ions.* The major dissolved gases such as carbon dioxide, methane, and hydrogen sulfide should be included. Information on ambient ground-water temperature should also be provided. If any of the information in the section is not currently available, discuss any plans for obtaining it within the context of the site characterization program in Part C of the SCR.

5.8 Ground-Water Uses

Identify the principal regional ground-water users, including locations, rates, typical well construction, and hydrogeologic unit source. Include irrigation, industrial, municipal, domestic livestock, and energy resource development uses. Identify areas of large ground-water pumping or injection on the regional hydrogeologic map. Include the extent of depression or impression cones on the potentiometric surfaces.

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*Field and laboratory analysis methods should conform to those in National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5, Federal Interagency Committee on Water Data, Office of Water Data Coordination, U.S. Geological Survey, Reston, Virginia, 1977-78.

5.8.1 Regional Ground-Water Aquifers Used for Human Activities

Identify the specific aquifer units that provide the sources for the ground-water uses identified in Section 5.8. Also present the relationship between ground-water use and aquifer storage and recharge to identify areas of stress on the aquifer and mining of the ground-water resource.

5.8.2 Regional Ground-Water Management Plans

Identify the regional ground-water management agencies and their programs. Also provide an assessment, using this information, of regional ground-water projections for the foreseeable future, preferably the next 50- to 100-year period. Include ground-water use, potentiometric level changes, and hydrochemical changes.

5.9 Site Hydrogeologic System

Describe the site hydrogeologic systems to the extent that available information will permit.

5.9.1 Baseline Monitoring

Provide information gathered from the baseline monitoring* program that includes seasonal variations, long-term trends in potentiometric levels, and hydrochemistry of the principal hydrogeologic units, if available.

5.9.1.1 Monitoring Network. Provide specifications and designs (i.e., locations, elevations of screens and measuring points, elevations of seals), selection process for choosing location and depth of data collection systems, hydrogeologic units being monitored, method and frequency of measurement, and method of hydrochemical sampling for the monitoring network used in establishing the baseline monitoring program.

5.9.1.2 Potentiometric Levels. Provide representative hydrographs and potentiometric surface maps for each principal hydrogeologic unit. The hydrographs should include precipitation, surface-water levels, and rates of groundwater pumpage where appropriate. Based on this information, provide completed assessment for the potential for long-term or significant short-term changes in the water levels, and indicate them on hydrographs and potentiometric maps.

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*Baseline monitoring means the establishment and operation of an engineered surveillance system for continuous measurement and recording of existing ground-water conditions that will serve as an historical data base for future observational comparisons.

5.9.1.3 Hydrochemistry. Provide the previously gathered information on the hydrochemistry of the principal hydrogeologic units. In characterizing each unit, identify the principal ions, dissolved gases, natural radioisotopes, Eh-pH values, organic components, temperatures, density of the fluid(s), and major ions. Using this information, provide completed assessments of temporal and spatial variations of the hydrochemistry.

5.9.2 Hydraulic Characteristics of Matrix and Fluid

Information on hydraulic characteristics of the matrix and fluid for each principal hydrogeologic unit and a discussion of statistical parameters and values should be provided. The methods of determination, range, and mean values should also be provided. The information should be grouped into separate sections for each hydrogeologic unit and should include the following characteristics:

1. Intrinsic Permeability (cm^2). Indicate whether the intrinsic permeability is developed by secondary processes such as fracturing, weathering, dissolution, or degassing of igneous rocks and the extent to which Darcian flow can be assumed.

2. Hydraulic Conductivity (cm/sec) and Transmissivity (m^2/day). Indicate the representative volume applicable and the saturated thicknesses assumed.

3. Total and Effective Porosity (dimensionless). Indicate the nature of the pore space, i.e., interstitial, fractured, or solutioning, and distinguish primary and secondary porosity.

4. Storage Coefficient. Indicate whether phreatic or confined conditions are constant throughout the region.

5.9.3 Ground-Water Flow System

Describe the ground-water flow system using the previously described hydraulic characteristics, and identify the accessible environment and credible pathways.

5.9.3.1 Accessible Environment and Credible Pathways. Identify the accessible environment associated with the conceptual design of a repository appropriate to the site. The credible pathways for ground-water transport from the conceptual design of a repository appropriate to the site to the accessible environment should also be identified.

5.9.3.2 Potentiometric Levels and Head Relationships. Provide a synthesis and analysis of potentiometric levels and head relationships as described in paragraph 5.6.3. Include hydraulic gradients, flow directions, and potential for variations.

5.9.3.3 Recharge-Discharge and Leakage. Provide information on completed investigations on the location and rates of recharge-discharge and leakage for the principal hydrogeologic units. Fully document these investigations. Where appropriate, constant head, no-flow, and constant flux boundary conditions should be identified and indicated on the appropriate hydrogeologic map. Provide plans to use the regional and site hydrochemical analyses to identify or verify the location of recharge, discharge, and mixing zones.

5.9.4 Ground-Water Velocity and Travel Time

Describe the method of determination and the ranges of values for the average interstitial velocities for Darcian flow conditions or the maximum velocities for fractured flow of the principal hydrogeologic units based on the representative elementary volume. Using the information gathered on credible pathways, indicate the expected range of advective travel times from the conceptual design of a repository appropriate to the site to the accessible environment.

5.9.4.1 Radionuclide Transport Factors. Provide information on the methods and the results of investigations performed to determine the factors influencing radionuclide transport for each hydrogeologic unit occurring in the credible pathway. The investigations and methods of analysis should take into consideration the temperature, viscosity, water chemistry, retardation, and oxidation-reduction potential within the hydrogeologic units and the projected thermal flux due to the emplaced waste.

5.9.4.2 Geothermal Gradient and Thermal Convective Component. Identify the existing geothermal gradient, and assess the effect of the thermal convective component introduced by the emplaced waste on the ground-water transport.

5.9.5 Hydrochemistry and Ground-Water Age

Describe the results of completed investigations of the hydrochemistry and ground-water age of each principal hydrogeologic unit. Include the tests and method of sampling performed and to be performed for the hydrochemical investigation.

Identify the isotopes (i.e., C^{14}, H^3, O^{16}/O^{18}, D/H, Cl^{36}) used for ground-water age determinations, including the field and laboratory techniques used, the range of values, and an error analysis of the results.

5.9.6 Monitoring and Verification

Provide information on the specific monitoring and verification programs, including their spatial and temporal distribution, implemented for the hydrologic system associated with the geologic repository.

5.9.6.1 Baseline Condition Changes. Specify the aspects of the monitoring program that will permit detection of baseline condition changes necessary to assess hydrologic stability, and provide an historical background.

5.9.6.2 Well Construction, Development, and Completion. Describe well construction and development techniques. Include such details as locations; elevations of screens and measuring data; hydrogeologic units encountered; method of development; types and locations of borehole seals, casing, and screen materials; mode of drilling; and method and schedule of development.

5.9.6.3 Monitoring Methods. Describe the method of sampling and/or surveillance used. Provide information on the indirect methods of sampling such as geophysical techniques and TV surveillance. Also provide information on the direct methods of sampling such as water sampling, potentiometric level readings, and pressure testing. Indicate the hydrogeologic information collected using each monitoring method.

5.9.7 Local Ground-Water Users

Identify all the local ground-water users, including locations, rates, typical well construction, and hydrogeologic unit source. Include irrigation, industrial, municipal, domestic livestock, and energy resource development users. Determine what effect, if any, the local ground-water users have on the site's ground-water flow system.

6. GEOCHEMISTRY

In this chapter present pertinent descriptions of the geochemical properties of the rocks, minerals, sediments, and water of the candidate area and site. Include anticipated geochemical reactions that have influenced the conceptual design of a repository appropriate to the site. Include generic data from similar rock types and site-specific information, if available. The information should be presented in sufficient detail to (1) permit an understanding of the geochemical factors of the candidate area and site, based on available literature and site-screening studies, and (2) support the planned site characterization program.

For each of the following sections, include the rationale for the values chosen. For natural variables (e.g., rock compositions and ground-water chemistry), indicate expected ranges of values and by what process these were assumed. For engineering variables (e.g., composition of backfill, waste form, canister, temperature, and pressure), indicate why these particular values were assumed and what is the reasonable range of expected values. For chemical and geochemical reactions (e.g., any of the reactions among the waste, water, rock, barrier, canister), indicate the rationale for the identification of these reactions (e.g., theoretical, laboratory experimental, observed in nature) and to what extent the nature of the reactions would be expected to change because of changing conditions at the site (e.g., changes in solubility of constituents in ground water resulting from heating the ground water).

6.1 Host Rock Geochemistry

For rocks and fracture fill materials along credible pathways to the accessible environment, describe the petrology and mineralogy of the rocks and material in the fractures. Describe the inferred or measured distribution and abundance of mineral phases that will affect radionuclide migration, and identify mineral assemblages and amorphous components that buffer pH and Eh of ground water.

6.2 Hydrogeochemistry

For the proposed host rock unit and other rock units along credible pathways to the accessible environment, provide the following information when available:

1. Major, minor, and trace-element composition of ground water, including organic and inorganic species, dissolved and suspended (i.e., colloids),
2. Ionic strength of ground water,
3. Complexing agents (organic and inorganic),
4. pH,
5. Eh (measured and calculated), dissolved oxygen, redox couples (i.e., Fe^{+2}/Fe^{+3}),
6. Temperature,
7. Pressure,
8. Gas composition,
9. Sorption-desorption isotherms, including those for fracture filling,
10. Sorption capacity,

11. Ion exchange,
12. Filtration,
13. Chemical substitution,
14. Isotopic exchange,
15. Diffusion into pores,
16. Acid-base,
17. Solution-precipitation,
18. Thermodynamic information,
19. Reaction mechanisms,
20. Impact of kinetic effects on retardation,
21. Retardation factors (Rf),
22. Mass distribution coefficient (Kd),
23. Surface distribution coefficient (KA),
24. Solubilities of radionuclides, and
25. Extent of solution saturation by potential precipitates.

Discuss the methods used to obtain the data as well as the QA programs applied to data collection. If information on any (or all) of these geochemical parameters is not available at the time the SCR is submitted, describe the proposed plans for obtaining this information during site characterization. (The proposed plans may be described in Part C.)

6.3 Chemistry of Waste, Barriers, and Environment of a Conceptual Design Repository Appropriate to Site

Describe anticipated interactions among the waste form, engineered barriers, and environment of a conceptual design of a repository appropriate to the site. Include analyses of generic interactions and, if available, include analyses of interactions of proposed specific waste forms and engineered barriers for the site.

Describe the anticipated (1) chemical composition and form of the waste, (2) solubility of the waste form in ground water under varying anticipated environmental conditions (e.g., temperature, oxidation states), and (3) species released by the leaching of the waste form under anticipated conditions.

Describe anticipated chemical and mineralogical composition of any barriers, solubility of these barriers under varying anticipated physico-chemical conditions, any changes in speciation imposed on radionuclides released from the waste, and speciation of wastes crossing the engineered barrier/natural geological systems boundary.

Describe anticipated interactions of the waste water and rock. Include (1) hydrothermal alteration of the proposed host rock during the thermal pulse, (2) changes in the chemistry of the ground water in the proposed host rock during the thermal pulse, and (3) the effect of changes of mineralogy and hydrology on the radionuclide migration.

6.4 Natural Analogs

Provide pertinent data, analyses, and current level of assessment of natural geochemical analogs to the site. Provide a basis for comparing and contrasting the analog environment with the site.

Describe any field tests from other sites that may be useful in interpreting expected results obtained from this site during site characterization.

6.5 Geochemical Stability

Describe the expected geochemical stability of the site. Include (1) potential human influences (i.e., solution mining, injection disposal, ground-water withdrawal, ground-water mining) and (2) natural changes due to climatic variation.

7. CLIMATOLOGY AND METEOROLOGY

Provide a description of the climatology and meteorology of the candidate area and site. An analysis of paleoclimatic conditions should provide an assessment of the climatic changes that might occur in the future, based on evaluations of the past and present climatic conditions. Paleoclimatic analysis should include at least the complete climatic spectrum ranging from maximum glacial to maximum interglacial conditions. Sources of the information and data provided should be referenced. Identify those areas where sufficient data or information are presently not available.

7.1 Recent Climate and Meteorology

A climatological and meteorological description should be provided for the candidate area and site.

7.1.1 Climate

The general climate should be described with respect to types of air masses, synoptic features and frontal systems, and general airflow patterns and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions. Climatological characteristics attributable to the terrain should be identified. Data should be provided in sufficient detail to indicate impacts on the conceptual design and potential operation of a repository at the site.

All information should be fully documented and should be based on data for the most recent 30-year record period. Sources of such information could include National Oceanic and Atmospheric Administration (NOAA) facilities such as the National Climatic Center (NCC) and the National Weather Service (NWS) stations; other government facilities (e.g., military stations); and private organizations such as universities that have maintained quality-controlled data collection programs. The validity of the information provided, with respect to representation of the conditions at and near the site, should be substantiated.

7.1.2 Local and Regional Meteorology

Plans for obtaining sufficient meteorological information to adequately characterize atmospheric dispersion processes (i.e., airflow trajectories, atmospheric stability conditions, depletion and deposition characteristics) within the candidate area should be provided.

7.1.3 Site Meteorological Measurement Program

The meteorological measurement program to be conducted to develop local data and programs that will be used to estimate offsite concentrations of effluents released during site characterization should be described. The information provided should include measurements made, locations and elevations of measurements, descriptions of the instruments used, instrument performance specifications, calibration and maintenance procedures, and data analyses procedures.

7.2 Long-Term Climatic Assessment

An analysis of paleoclimatic conditions at the candidate area and the site should be provided. Based on this analysis and on recent climatic characteristics of the candidate area, an assessment of the magnitude and rate of climatic changes that might be expected to occur in the future should be provided. The information should be presented in sufficient detail to indicate impacts on long-term isolation of the waste.

7.2.1 Paleoclimatology

Provide an analysis of the Quaternary paleoclimatology of the candidate area and the site, including atmospheric, hydrospheric, and cryospheric aspects of the successive climatic regimes, in the context of determining the magnitude of the climatic changes and the rates at which the changes occurred. Changes in precipitation regimes, locations of potential aquifer recharge areas, glaciated areas, and windflow patterns should be identified. Geological, biological, and ecological evidence to support the analysis should be provided. Information should also be provided on the size (areal extent and thicknesses) of any glaciers and on accumulation and ablation rates. The impacts of any glaciers on precipitation regimes and windflow patterns should be discussed. Relationships between air temperatures and regional precipitation, in relationship to the water balance of the area, should also be discussed.

Sources of all information should be provided. The validity and applicability of the information provided, with respect to the representation of conditions at and near the site, should be substantiated.

7.2.2 Future Climatic Variation

An estimate of the potential impact of climatic change on precipitation patterns, windflow regimes, the cryosphere, and sea levels should be discussed.

Based on the reconstruction of the paleoclimate and the recent climate, long-term estimates of the following should be provided:

1. Potential maximum and minimum changes and rates of change in precipitation and air temperature from the present that could be expected to occur,

2. Potential regional windflow and precipitation patterns that may evolve in the future as a result of climatic and geologic changes,

3. The potential for glaciation, including estimates of times of onset of glaciation and lengths and severity of glacial regimes in the site area, and

4. Future fluctuations in sea levels and cryosphere due to climatic changes.

All procedures, including models, used in the climatic extrapolations should be identified, as should all assumptions and areas where insufficient data make extrapolations questionable.

7.2.3 Site Paleoclimatic Investigation

Describe how information obtained during the site characterization stage will be used to increase the data base concerning the paleoclimatology of the area. This could include the examination of sediment core samples for fossil pollen, ancient soil types, lake sediment varve sequences and thicknesses, etc. The application of the information thus developed to supplement places where data are sparse or lacking in the initial investigation should be emphasized. Any changes in the paleoclimatic assessment that results from this investigation should be reflected by revisions to the future climatic condition extrapolations.

8. CONCEPTUAL DESIGN OF A REPOSITORY

Provisions for the inclusion in the SCR of a conceptual design of a respository* appropriate to the named site are set forth in paragraph 60.11(a)(6)(ii). Information on the conceptual design of a repository is needed to allow an assessment of the site characterization program since a substantial amount of the information generated during site characterization will directly relate to the progressive development of a repository design for the site. It is recognized that the conceptual design repository presented in the SCR will be preliminary in nature and may be modified or refined as a result of site characterization activities. Consequently, it is necessary to know at the SCR stage which portions of the conceptual design of a repository are based on results developed during preliminary site exploration activities and which portions are based on assumed parametric values or anticipated site conditions. All assumptions of parametric values (e.g., in situ stress field) and site conditions (e.g., ground-water hydrology) should be clearly documented in the SCR. Assumptions that will be confirmed or refined during site characterization should be noted. To the extent possible, the design bases, design assumptions, preliminary design criteria, and preliminary analyses that have been performed to develop the conceptual design of a repository should be stated.

The information presented in this chapter should be of sufficient detail (1) to permit an understanding of the conceptual design of a repository and its relationship to the site and prospective host rock and (2) to permit an evaluation of the relationship of the planned tests and experiments during site characterization to the resolution of design issues and to the development and modification of the conceptual design of a repository.

8.1 Design of Underground Openings

Provide the general layout and design of proposed subsurface openings in plan and cross section, and show their relationship to proposed plans for in situ testing at depth and to known or inferred geologic and hydrologic conditions of the site. If known, identify proposed locations of shafts and their relationship to the proposed plan for in situ testing at depth and known or inferred subsurface conditions. Provide shaft stability factors based on inferred subsurface rock stresses and ground-water conditions and their relationship to the proposed test shaft(s). Provide the basis used in determining the proposed sizing, shape, and orientation of the major subsurface openings. Include discussions of those considerations given to ground-water conditions, thermal output, the natural and thermally induced stress field, and the need for ventilation. Identify and discuss separately any design limitations due to factors not directly related to waste isolation but to the constructability or operability of the repository. Include factors such as minimum space required for emplacement of the waste, layout requirements for separation and control of excavation and waste emplacement operations, ventilation requirements, and worker safety considerations.

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*As used in this guide, the conceptual design of a repository means a design of a repository appropriate to the named site in sufficient detail to allow assessment of the site characterization program with respect to investigative activities that address the ability of the site to host a repository and isolate radioactive waste or that may affect such ability.

8.2 Backfill

Describe the proposed characteristics and functions of the backfill in the conceptual design of a repository. Identify any proposed backfill materials being considered for use at the site. Provide the mechanical properties of the proposed backfill that are critical for the site and design (use ASTM or other applicable standards, as appropriate). Discuss the relationship between the mechanical properties of the proposed backfill and the expected conditions at the site (e.g., temperature, moisture, stress). Describe the geochemical characteristics of the backfill materials, as well as the anticipated chemical interactions among the waste package, backfill, ground water, and host rock under assumed waste emplacement conditions. Identify the measured or inferred material and site parameters used to estimate those reactions. (The geochemical discussion here should be in sufficient detail to describe the geochemical role of the backfill at the site. The full descriptions of the geochemical investigations and the nature of backfill, waste form, package, rock, and ground-water interactions should be provided in Chapters 6, "Geochemistry," or 9, "Waste Form and Package.")

8.3 Strength of Rock Mass

Provide preliminary design values used for the mechanical properties of the rock, including elastic and inelastic behavior of the rock mass, the thermomechanical behavior of the rock mass, and the mechanical behavior of rock discontinuities (e.g., joints, bedding planes, shear zones). Describe how they were determined. (The rock mechanics information should be presented here in sufficient detail to describe the relationship of the rock properties to the design. The full description of the rock mechanics background should be presented in Chapter 4, "Geoengineering.") Describe how these values for the mechanical and thermomechanical behavior of the rock were used in developing the conceptual design of a repository. Present the results of model studies used in developing the conceptual design of a repository appropriate to the site.

8.4 Sealing of Shafts, Boreholes, and Underground Openings

Describe the proposed treatment of the disturbed section of rock around openings and excavated surfaces. Describe proposed design measures to control ground-water movement into the facility. Provide laboratory and field data when available and inferred site conditions on which the selection of the treatment measures was based. Describe the proposed design for the sealing of boreholes and shafts. Provide laboratory and field data and inferred site conditions on which the design was based. Provide the mechanical, chemical, and hydrologic properties of proposed sealing materials.

8.5 Construction

Describe construction techniques being considered for potential repository development at the site. Describe in detail any known or inferred site conditions requiring specialized construction techniques. Describe planned actions to be taken so that construction of exploratory workings at the site would not compromise the integrity of the site.

Describe methods under consideration for breaking and removing rock during construction. Assess the potential impacts of construction on fracturing, and note any special precautions needed to minimize propagation of fractures that could be potential pathways, taking into consideration the inferred rock conditions at the site proposed for characterization. Describe the geotechnical factors expected to bear on the suitability of proposed excavation techniques and their relationship to any information obtained during exploratory drilling. Mechanical excavation methods, controlled blasting, or other measures proposed to be used in the construction of underground openings should be described and related to known or inferred rock conditions and the stability of the conceptual design of a repository. (The full description of excavation investigations should be given in Chapter 4, "Geoengineering.") Describe temporary or permanent support structures proposed and their relationship to the basis of the conceptual design. The methods planned to be used to control, collect, and dispose of ground water during excavation and the relationship of the planned methods to ground-water information obtained from exploratory investigations should be described.

8.6 Design of Surface Facilities

Provide a description of properties of surface materials and foundation soil or rock considered in the design of structural foundations for surface facilities. Describe expected or known soil and rock conditions and the depth to and quality of foundation soil or rock. Discuss any known or inferred foundation problems. Also, describe sources of water for construction and operation of the proposed facilities.

9. WASTE FORM AND PACKAGE

Evaluate the principal candidate waste forms and packages that may be considered appropriate for the site, and describe how the range of environments anticipated at the site and the resulting design limits would affect these waste forms and packages. To the extent that the information is available prior to site characterization, describe and compare alternative waste forms and packages being considered and their development programs. Provide a basis for evaluating the adequacy of the information to be produced in the site characterization program.

9.1 Description

Describe the candidate waste forms (including physical form and mechanical properties, chemical form and properties, radionuclide inventory, thermal output, expected temperatures, and radiation released) and waste packages (including types of packaging and their properties, container size and shape, and the weight, volume, and number of the containers to be emplaced).

9.2 Design Concepts

Describe the waste form and package design concepts considered appropriate for the site and conceptual design of a repository appropriate to the site. Discuss the independent barriers within the waste package and estimates, if available, of the reliability of these individual barriers.

9.3 Research and Development

Describe the status of research and development on appropriate waste forms and packages as it relates to characterization of the site, including research planned or under way to evaluate the performance of such waste forms and packages.

9.4 Emplacement Environment

If candidate waste packages and materials have been identified, describe the type of environment into which the waste form and packaging may be placed. Include upper bounds that could be expected for:

1. Chemical conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include appropriate thermodynamic equilibria, oxidation/reduction reactions, corrosion, electrochemical reactions, leaching, dissolution, and gas generation.

2. Physical conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include thermal effects, mechanical strength, and mechanical stress.

3. Nuclear conditions and processes within and between the waste package and its environment that could compromise or enhance the ability of the waste package to support the performance objectives. Include radiolysis, potential radiation damage, and potential criticality.

9.5 Alternative Waste Forms and Waste Packages

Sufficient information about alternative waste forms and waste packages should be provided to show full integration of the criteria and decision processes for site selection with those for waste form and waste package selection.

PART C

STANDARD FORMAT AND CONTENT GUIDANCE FOR PRESENTING SITE CHARACTERIZATION PROGRAM

While Parts A and B of the Standard Format provide guidance on the presentation of what is already known about a site, Part C deals with what DOE plans to do in site characterization.

Part C of the Standard Format specifies that the SCR should:

1. Identify issues (questions about a site that are critical to making the findings required by 10 CFR Part 60 for construction authorization);

2. Specify information needs required to make findings on unresolved issues; and

3. Describe the planned methods of data acquisition synthesis and analysis to meet information needs for unresolved issues.

There should be a brief evaluation of the significant options available for resolving issues and for methods of testing and analysis that will reduce the limitations and uncertainties of the tests, methods, data, and interpretations of data. Both the surface testing and in situ testing-at-depth aspects of the planned site characterization program should be included.

The SCR will be principally evaluated according to the completeness of Part C, its most critical part.

In developing Part C of the SCR, DOE should ensure that attention is focused on those aspects of siting, development of waste form and packaging, and conceptual design of a repository that will require the most effort in the site characterization program. While the SCR must be complete in developing the issues of site characterization, it is important--particularly in initial planning phases--that those issues considered critical or most important be identified and given highest priority in the site characterization plan.

10. SITE CHARACTERIZATION PROGRAM

This chapter should provide the rationale behind the proposed site characterization program and should describe in detail the program of exploration and testing to be conducted during site characterization. The description of the site characterization program at the named site should include (1) the issues to be resolved and information to be acquired during site characterization, (2) the tests and experiments to be performed, (3) schedule, sequence, and duration of testing and data analyses, (4) the extent of planned excavation and in situ testing at depth, (5) elements of the conceptual design of a repository appropriate to the site relevant to data acquisition, analyses, and scheduling, (6) key milestones against which the progress of site characterization can be measured, (7) provisions to control any adverse, safety-related effects that may result from site characterization, and (8) the quality assurance methods to be used in data acquisition and analysis. Also to be noted should be the decision points at which the direction of the site characterization program might be changed if warranted by the results obtained.

10.1 Rationale for Planned Site Characterization Program

This section should provide the rationale for the planned site characterization program. This rationale should include a summary discussion of (1) the types of information to be obtained during site characterization; (2) why the information is needed; and (3) whether the information will provide confirmatory or supplemental data and analyses to existing data and analyses or whether the information will be acquired in areas not addressed during site exploration activities. The following sections of this chapter should be appropriately referenced in this rationale. The objectives of the site characterization program should be clearly stated and the relationship between the information presented in Parts A and B and the planned site characterization program clearly established.

10.2 Issues To Be Resolved and Information Required During Site Characterization

This section should identify all known issues related to siting, design of a geologic repository operations area, and waste package and performance assessment as specified in proposed 10 CFR Part 60. The following sections (10.2.1-10.2.4) should contain discussions of the types of information needed to resolve the issues, including, but not be limited to, the following areas of study:

1. Geomorphology,
2. Stratigraphy,
3. Structural geology,
4. Tectonics,
5. Seismicity,
6. Rock mechanics,
7. Hydrology (surface and ground water),
8. Geochemistry,
9. Climatology,
10. Meteorology, and
11. Waste-host rock interactions.

For each of these areas of study, discuss whether the necessary data will be collected from surface or subsurface portions of the planned site characterization program. If any information need is directly related to either the further development of the conceptual design of a repository appropriate to the site or to modeling efforts, this fact should be clearly stated.

Proposed plans for resolving unresolved issues during site characterization, including the specifications for performing the investigations and the applicability and limitations of the investigations for resolving the issues, should be described.

10.2.1 Unresolved Issues Related to Site Selection

Describe any unresolved issues related to the selection of the site for characterization. This description may include issues related to alternative sites, ownership and control of the site, or the identification of favorable siting conditions (e.g., geochemical conditions that promote sorption of radionuclides) or potentially adverse conditions (e.g., active faulting).*

Summarize the extent to which preliminary site exploration activities contributed to the identification of the siting issues. Discuss information obtained during site exploration activities that has led to a partial resolution of the issues.

10.2.2 Unresolved Issues Related to Design of Geologic Repository Operations Area

Describe unresolved issues related to the design of the geologic repository operations area. Identify site characterization plans proposed to obtain information to resolve these issues.

10.2.2.1 Verification or Measurement of Site Conditions. Describe those issues related to site conditions (e.g., host rock, in situ stress field) that are part of the design bases that must be verified or measured during site characterization to verify the compatibility of the proposed conceptual design of a repository and the geologic repository operations area.

10.2.2.2 Design Optimization Issues. Describe the design optimization issues that necessitate data acquisition during site characterization. These are issues in which a structure or material has conflicting performance requirements (e.g., thermal-loading for 1 acre vs. repository size) and an optimum will be determined from investigations during site characterization.

10.2.3 Unresolved Issues Related to Waste Form and Package

This section should identify the issues related to the waste form and waste package, including the emplacement environment, that were not resolved by preliminary site exploration activities or by research and development conducted prior to the submittal of the SCR. Site-specific plans to resolve these issues during the site characterization program should also be included.

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*Siting conditions that NRC would categorize as favorable or potentially adverse may be found in proposed 10 CFR Part 60.

10.2.4 Performance Assessment Issues

10.2.4.1 Substantially Completed Analytical Techniques. Describe those performance assessment techniques, including simplifying assumptions and boundary conditions, for which development work is substantially complete, with particular emphasis on identification of the types and quality of data needed and on the plans for verification or validation of performance assessments during or after site characterization. In the description, specific sections from other documents such as user manuals and code documentations may be incorporated by reference provided these documents are either publicly available or, if proprietary, are readily available to the NRC.

10.2.4.2 Analytical Techniques Requiring Significant Development. Describe those analytical techniques that are expected to be important for evaluating the performance of the site but that still require significant additional developmental work at the time the SCR is prepared. Include site-specific and generic models and computer codes. Describe the programs formulated for undertaking the developmental work during site characterization.

Describe both the analytical techniques expected to be important for site analysis and the associated data requirements. Available data should be summarized in this section either directly or by reference to other chapters of this report. For each type of analysis, anticipated simplifying assumptions and boundary conditions should be described.

10.2.5 Issues for NRC Review

In this section, any issues related to site selection, alternative candidate areas or sites, or design of the geologic repository operations area that DOE wishes the NRC to review should be presented.

10.3 Planned Tests and Experiments

Planned tests and experiments to be conducted during site characterization should be described in detail. The relationship of the planned tests and experiments to information presented in Parts A and B and to the unresolved issues discussed in Section 10.2 should be clearly stated. The quality assurance program to be applied to data collection during site characterization should also be described.

Suggested Format for Description of Planned Tests and Experiments

1. Title of Test or Experiment.
2. Purpose of Test or Experiment - Summarize why the test or experiment is proposed and what types of information will be obtained.
3. Objective(s) - Discuss how the results of the test or experiment will relate to the overall site characterization program. Describe how the results will be used to help resolve specific information needs or unresolved issues.

4. Descriptive Summary - Summarize the methods, techniques, and analyses used in the test or experiment. Describe in detail the procedures expected to be used.

5. Quality Assurance - Describe the quality assurance program to be applied to data collection, and discuss the limitations and uncertainty in the data.

6. Principal Investigator - Give the name and organization of the principal investigator, if known.

7. Contact - Provide the name, address, and telephone number of the person(s) to contact concerning the status of the test or experiment.

10.4 Planned Testing, Instrumentation, and Monitoring

For each test or experiment described above, the testing and instrumentation that will be necessary for the investigation should be described. The description should include testing method and testing apparatus, data collection systems, methods of analysis and reduction of data, and the applicability and limitations of the testing and instrumentation in acquiring the necessary information.

For each test or experiment requiring short-term or long-term monitoring, the monitoring goal and technique(s) should be described. The description should include specifications for the monitoring system, the instrumentation and data collection systems, the methods of analysis and reduction of data, and the applicability and limitations of the monitoring system in acquiring the necessary information. Identify and evaluate alternative methods of testing and analysis that might achieve the same goals as the methods proposed.

10.5 Planned Site Preparation Activities

In this section, plans for surface and subsurface excavations related to the site characterization program should be presented.

10.5.1 Surface Site Preparation Activities

Describe the surface activities (e.g., construction) needed to prepare the site for site characterization activities. Include the anticipated start and completion dates. State whether the surface activities are related to site characterization at the surface or whether they are preparatory to subsurface activities. Describe any surface facilities to be erected at the site.

10.5.2 Underground Test Facility

Describe the underground test facility to be used for the in situ testing-at-depth portion of the site characterization program. The description should include a detailed layout of the planned excavation, boring locations, and the planned location within the test facility of each anticipated test or experiment. In addition, details of construction, including the location of the underground test facility with respect to the conceptual design of a repository appropriate to the site, should be provided. Particular attention should be paid to shafts excavated and borings made for the underground test facility and their location with respect to possible future shafts and excavations. An analysis of the potential impact of in situ testing at depth on the integrity of the site should also be included.

10.6 Milestones, Analyses, Decision Points

Describe briefly (1) key milestones to be used to mark progress, (2) data analyses to be performed, (3) use of acquired data, including both direct use of the tests and experiments as well as integration of results of tests and experiments to resolve identified issues or to identify new issues, and (4) stages in the site characterization program when options would be assessed and decisions would be made as to how (or whether) to proceed.

10.7 Schedule

Provide a graphic presentation (flow chart) of the site characterization program in which activities, analyses, milestones, decision points, reports, and submittals for NRC, State, Indian tribal, and public review and any other relevant information are identified. The presentation should be constructed so that tasks accomplished and tasks still to be accomplished can readily be identified. The presentation should also include, as appropriate, the logic leading to decision points and selection among alternatives.

APPENDIX A

SEMIANNUAL REPORTS

In accordance with paragraph 60.11(g) of 10 CFR Part 60, DOE must submit semiannual reports to NRC on the progress of site characterization and of waste form and packaging research and development.

These semiannual reports should:

1. Discuss the results of site characterization activities,

2. Identify (a) new issues not previously mentioned in the SCR; (b) plans to resolve these issues; (c) those studies originally planned that are no longer considered necessary and therefore eliminated from the site characterization program; (d) decision points reached during site characterization; and (e) modifications to schedules, and

3. Report progress in developing the design of a geologic repository operations area appropriate to the site.

The NRC does not believe that it is necessary to issue a separate regulatory guide on the format to be used for these semiannual reports. To the extent appropriate, however, this Standard Format provided for the SCR may be used when submitting information in the semiannual progress reports.

VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

Sections 202(3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the NRC with licensing and regulatory authority regarding Department of Energy (DOE) facilities used primarily for the receipt and storage* of high-level wastes (HLW) resulting from activities licensed under the Atomic Energy Act and certain other long-term, HLW storage facilities of the DOE. The NRC has issued regulations appropriate for licensing geologic disposal of HLW by DOE in 10 CFR Part 60 (46 FR 13971). Provisions requiring that a program of site characterization be conducted at a minimum of three sites, at least one of which is not salt, prior to the submittal of an application for a license to be issued under 10 CFR Part 60 are set forth in § 51.40 of 10 CFR Part 51. When DOE has formulated preliminary plans for a prospective repository to the extent that site characterization may begin, but prior to the commencement of site characterization at a particular site, DOE must submit a site characterization report (SCR) to NRC.

In order to provide DOE with guidance concerning the types of information and the level of detail that NRC considers appropriate for an SCR and to facilitate NRC review of the SCR, it is proposed that this regulatory guide be published.

1.2 Need for Proposed Action

This regulatory guide is needed so that DOE will be informed in a timely manner of the types of information that NRC feels may ultimately be needed for a license application, i.e., sufficient information about DOE's preferred site to support a finding, prior to construction of a geologic repository, of reasonable assurance that there is no unreasonable risk to public health and safety. Use of the format presented in this regulatory guide in providing the types of information requested in the SCR will help ensure the completeness of the information, will assist the NRC staff as well as States, Indian tribes, and the public in locating specific types of information, and will substantially shorten the time needed by the NRC staff during the review process. For some sites, the amount of information accumulated during preliminary site exploration activities prior to site characterization may be voluminous, and use of the proposed guide will aid in the identification and location of information pertaining to particular issues of interest to both NRC and non-NRC reviewers.

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*The NRC interprets "storage" as used in the Energy Reorganization Act to include disposal.

1.3 Value/Impact of Proposed Action

1.3.1 NRC Operations

The proposed guide sets forth the information that NRC anticipates will be needed to review both DOE's process of site selection and plans for site characterization. It is expected to improve consistency in the review of SCRs because of more uniform submittals and to reduce the review effort of the NRC staff.

The review of the SCR may involve an estimated 10 person-year effort (including both NRC staff and contractors/consultants).

1.3.2 Other Government Agencies

The regulatory guide will contribute to the reduction in time required for DOE's preparation of an SCR. Further, the regulatory guide should provide guidance with respect to the types and quality of information that may be needed to support a future application for construction authorization at DOE's preferred site. This guidance for future actions should result in a more efficient effort by DOE. It is not possible at this time to estimate the cost that may be incurred by DOE in following the format set forth in the regulatory guide for SCR submittals since both the level of effort and the amount of information accumulated at each site during preliminary site exploration activities will be variable parameters. Further, some preparations for the submittal of the SCRs may have been conducted by DOE contractors and consultants. However, the proposed regulatory guide should result in a cost reduction to DOE in submitting the SCR because it provides guidance on the specific types of information NRC expects to review, as well as on the level of detail and the reliability of the information. Cost reductions should be attributable to factors such as minimizing the amounts of original data to be submitted, allowing incorporation of certain information by reference from existing DOE environmental impact statements, and providing guidelines to minimize the submittal of superfluous information.

NRC interagency agreements currently exist with both the Bureau of Mines and the Army Corps of Engineers. It is estimated that each of these agencies may spend 1 person-year in reviewing each SCR submitted to NRC. Other Federal government agencies such as the Geological Survey, the Environmental Protection Agency, and the Bureau of Land Management have frequently commented on 10 CFR Part 60 during the rulemaking process, and it may be possible that some, if not all, of these Federal agencies may independently decide to review the SCRs. In any event, the regulatory guide should reduce the time needed by other Federal agencies to review the report(s).

1.3.3 Industry

Since DOE alone is responsible for the submittal of an SCR to NRC, the industry should not be affected by the proposed regulatory guide.

1.3.4 Public

The regulatory guide should be beneficial to the public since it will identify the types of information NRC is requesting from DOE and should facilitate review of the SCR. The required submittal of the SCR to NRC will also benefit the public because NRC will then transmit copies of the report to appropriate State, Indian tribal, and local officials and will make a copy available at the NRC Public Document Room. These actions should ensure early public awareness and involvement in the review of DOE's planned site characterization program.

There could also be cost reduction to the public resulting from improved efficiency during the review process.

1.4 Decision on Proposed Action

The publication of the regulatory guide on the suggested format to be used by the DOE when submitting SCRs should be undertaken.

2. TECHNICAL APPROACH

2.1 Technical Alternatives

1. Review the SCRs using modifications of existing NRC regulatory guides.

2. Allow DOE to submit, without formal NRC guidance, SCRs based on its perception of the types and level of detail of information that NRC would anticipate reviewing.

2.2 Discussion and Comparison of Technical Alternatives

The first alternative listed above would require the review of SCRs, using modified versions of previously published NRC regulatory guides. This alternative would appear to have a number of disadvantages. First, the proposed regulatory guide differs from a number of existing NRC guides in that the SCR will be submitted during the prelicensing stages and will contain a substantial amount of information on planned site characterization programs in addition to results of earlier studies. These two characteristics of the SCR would distinguish it from reports associated with licensing actions. Therefore, the emphasis of the regulatory guides associated with licensing would not be appropriate, even if modified, to the SCR.

Secondly, the NRC staff, in developing the proposed regulatory guide has considered the types of information it would expect to review in an SCR. If other NRC guides were modified for the SCR it might be possible that important information needs would not surface in a timely manner. Further, it would not be efficient use of staff time to search through other regulatory guides for a "best fit" guide. The SCR is an entirely new document, as the prelicensing and licensing stages of HLW disposal in geologic repositories are new stages.

The second technical alternative would be to allow DOE to submit the SCRs without the guidance provided by the proposed regulatory guide. While this approach could initially save the NRC the costs of developing and publishing the regulatory guide, the overall long-term cost to the Federal government could exceed such initial savings. Without a regulatory guide, DOE would be faced with the problem of trying to anticipate the informational needs of NRC. Lack of initial guidance from NRC could result in the submittal of an SCR with too little or too much detail for this stage of the prelicensing process. If DOE decides to err on the side of submitting too little detail, then the SCR submittal could be substantially delayed while DOE accumulates the additional information. Furthermore, without NRC guidance DOE might initiate certain types of drilling and testing to obtain data prior to the submittal of the SCR that may be more appropriately conducted after the commencement of site characterization. This in turn could impact site characterization itself as well as NRC's intention for early involvement in site characterization.

2.3 Decision on Technical Approach

Early guidance should be developed for the preparation of SCRs.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

Alternative procedural approaches that may be used to provide formal guidance to DOE include:

- Regulation
- Preparation of a regulatory guide
- Branch technical position

3.2 Value/Impact of Procedural Alternatives

3.2.1 Regulation

The advantages of a regulation are that it has the force of law and it is binding on the applicant as well as the NRC staff. Regulations are developed in full public view, following a series of formal steps that entail internal review and external review by the technical community. Public comment is invited on a proposed regulation prior to its adoption by the Commission. The formality of the process affords ample opportunity for all views to surface. In this manner, the ramifications of a proposed regulation and possible alternatives can be evaluated. Open participation by the public and technical community in producing the licensing requirements will add to public confidence in HLW disposal.

In general, regulations can be in the form of overall performance objectives, specific prescriptions to be adhered to by the licensee, or some combination of the two. In areas where a body of operating and licensing experience has been acquired with time, regulation by prescriptive requirements is the most efficient and least ambiguous method available. However, in the case of geologic disposal, there is no body of experience upon which to draw requirements for a regulation.

The NRC has developed the regulations for the disposal of HLW in geologic repositories - 10 CFR Part 60. Provisions for the general types of information to be included in the SCRs are set forth in § 60.11.

3.2.2 Regulatory Guide

Regulatory guides contain recommended procedures that NRC considers acceptable for meeting a given objective, but an applicant is not obligated to follow them. If the applicant adopts a different approach, the applicant will have to demonstrate that any alternative it chooses will produce acceptable results. Because of time and expense, an applicant may forego this option and adopt the methods suggested by regulatory guides. The advantages of regulatory guides lie in that they can be developed and changed more readily than regulations. This is because the procedures for developing them are not as formal as for regulations. Consequently, regulatory guides are more responsive to changing technology.

3.2.3 Staff Position Paper

Staff position papers (also known as Branch technical positions) are a statement by the staff, usually at the Branch level, of a position on a regulation. There are few formalities in their development. In particular, there is no public review so they can reflect technological changes very rapidly. The lack of external review can be both an advantage and a disdvantage. It allows for quick action; however, if the position is not carefully thought out, it may inadvertently complicate matters. Other ramifications of position papers are that (1) they are not binding on an applicant and (2) they may result in different criteria being applied to different applications if there are too many changes in the staff position papers.

3.3 Decision on Procedural Approach

A regulatory guide would be the most effective means to provide DOE with insight on the types of information and the level of detail NRC would consider appropriate at the time an SCR is submitted. Although 10 CFR Part 60 contains provisions mandating the inclusion of certain types of information in the SCR, it is not always explicit as to what level of detail would be expected. Further, the SCRs primarily address aspects of the earth sciences, e.g., geology, hydrology, climatology. The submittal of prolific amounts of information, all of which may not necessarily relate to the planned site characterization program, could result.

Branch technical positions may be developed by the NRC staff during the prelicensing stages of site exploration and site characterization with respect to particular issues that may arise. However, since the SCRs will address a number of varying issues (e.g., decision process, field work, future testing plans), the development of Branch technical positions may be neither feasible nor appropriate to the initial prelicensing stages.

The publication of a regulatory guide would serve to elaborate on the types of information that could be submitted in responding to the provisions set forth in § 60.11 of 10 CFR Part 60. The regulatory guide could also be more readily modified if deemed necessary. A draft regulatory guide was published for public comment in April 1981. The public comments received have been taken into consideration in the development of this guide. Therefore, there has been opportunity for the public to comment not only on the provisions for the SCRs set forth in 10 CFR Part 60, but also on the guidance suggested by the draft regulatory guide.

4. STATUTORY CONSIDERATION

4.1 NRC Authority

Sections 202(3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the Commission with licensing and regulatory authority regarding DOE facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the Atomic Energy Act and certain other long-term HLW storage facilities of the DOE. Pursuant to that authority, the Commission has developed criteria (10 CFR Part 60) appropriate to regulating geologic disposal of HLW by the DOE. To implement those provisions of 10 CFR Part 60 concerned with the submittal of an SCR by DOE to NRC, an active regulatory guide should be developed.

4.2 Need for NEPA Statement

The proposed action to develop a regulatory guide for the submittal of the SCR is not a major Federal action, as defined in paragraph 51.5(a) of 10 CFR Part 51 and does not require an environmental impact statement. However, NRC has prepared environmental impact appraisals during the rulemaking process on 10 CFR Part 60 which this regulatory guide implements.

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

The proposed regulatory guide has been prepared to implement paragraph 60.11(a) of 10 CFR Part 60.

6. SUMMARY AND CONCLUSIONS

In regard to the types of information and level of detail appropriate to SCRs, the NRC should provide guidance to DOE through a regulatory guide. Such guidance will aid in minimizing misunderstandings or misinterpretations of NRC's intentions not only with respect to the nature of the information to be included in the SCR but also with respect to the timing of the submittal of the SCR. The regulatory guide will also serve to provide discussion on why NRC is requesting specific information. Since opportunity for public comment on the draft guide has already been provided and has been considered during the development of the active guide, it is recommended that the active guide be issued.

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U.S. NUCLEAR REGULATORY COMMISSION July 1982

REGULATORY GUIDE

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REGULATORY GUIDE 5.63
(Task SG 126-4)

PHYSICAL PROTECTION FOR TRANSIENT SHIPMENTS

A. INTRODUCTION

Section 70.20b of 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," provides for general licensing of any person to possess transient shipments of formula quantities of strategic special nuclear material (SSNM).* A transient shipment is a shipment of nuclear material originating and terminating in foreign countries on a vessel or aircraft that stops at a United States port. Persons carrying transient shipments are required under the general license to provide physical protection, including the use of armed guards, for transient shipments while the shipment remains in a U.S. port. The physical protection system provided must be in accordance with or equivalent to that required for U.S. domestic shipments of formula quantities of SSNM under the applicable provisions of paragraphs 73.20(a) and (b) and § 73.25 of 10 CFR Part 73, "Physical Protection of Plants and Materials."

A general licensee for a transient shipment (e.g., a carrier) is not required to submit applications or security plans for prior approval by the Nuclear Regulatory Commission (NRC) as are licensees for domestic shipments of formula quantities of SSNM. However, the licensee is required to prepare such plans and to implement them during stops at U.S. ports.

This guide describes measures acceptable to the NRC staff that can be taken by the licensee to provide the physical protection for scheduled and unscheduled transient shipments required by 10 CFR Part 70.

B. DISCUSSION

1. BACKGROUND

General licensees under § 70.20b of 10 CFR Part 70 are required to provide physical protection for transient shipments of formula quantities of SSNM in accordance with or equivalent to the physical protection requirements for similar types and quantities of material in domestic shipments. These requirements are stated in 10 CFR Part 73 in terms of general performance objective and requirements [paragraphs 73.20(a) and (b)] and performance capabilities [§ 73.25].

The general performance objective and requirements indicate the level of protection to be provided by the licensee's physical protection system relative to the design basis threat (defined in § 73.1). The performance capabilities define in a systematic way the capabilities the physical protection system must have in order to meet the general performance requirements. In addition, § 73.26 describes a "reference system" containing brief descriptions of systems, subsystems, and procedures the NRC believes would generally be part of a physical protection system that achieves the objective and meets the requirements of §§ 73.20 and 73.25 for domestic shipments. However, the reference system does not necessarily describe a complete system that would meet all the physical protection requirements for U.S. domestic or transient shipments. Additional or alternative measures may be needed depending on the particular circumstances under which protection is to be provided.

The level of protection to be provided would be equivalent to that afforded formula quantities of SSNM in domestic shipments but may differ in detail depending on the circumstances peculiar to a given transient shipment. That is, the physical protection afforded a transient shipment would have to satisfy the general performance objective and

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*"Formula quantity" means strategic special nuclear material in any quantity of 5,000 grams or more computed by the formula: grams = (grams contained U-235) + 2.5(grams U-233 + grams plutonium). "Strategic special nuclear material" means uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

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requirements of paragraphs 73.20(a) and (b) and the performance capability requirements of § 73.25 but may be less complex because (1) the stopover times for transient shipments are short, (2) there is no need to offload the shipment from the transport, and (3) the number of persons, if any, required to have access to the shipment is limited.

2. ALTERNATIVE APPROACHES FOR MEETING REQUIREMENTS

General licensees for transient shipments of formula quantities of strategic special nuclear material may meet the physical protection requirements for such shipments in one of two ways:

1. The licensee may contract for physical protection services from a person (or organization) already authorized by the NRC to protect formula quantities of SSNM in transit, or

2. The licensee may undertake to directly provide the required physical protection in accordance with the provisions of the general performance requirements and performance capabilities of §§ 73.20 and 73.25.

3. PHYSICAL PROTECTION PLAN

A physical protection plan in written form is required to be followed in providing physical protection for the transient shipment. Although this plan does not have to be approved by the NRC in advance of the shipment, it must be provided along with the written notification to the NRC staff required by paragraph 70.20b(d) before the shipment first arrives in a U.S. port.

In the case of unscheduled transient shipments, i.e., those resulting from exigent circumstances or route or schedule changes that require stops at U.S. ports not on the transport's itinerary at the time the SSNM was loaded aboard, the licensee may not have the same opportunity for advance planning as in the case of scheduled shipments. However, the licensee is required to notify the NRC and begin making physical protection arrangements immediately after the decision is made to stop at the U.S. port. Although at the time SSNM is loaded aboard an aircraft or vessel carriers may not intend to stop at a U.S. port, the knowledge (1) that they are carrying SSNM in formula quantity and (2) that their itinerary brings them through or near U.S. territory (i.e., territorial waters or air space) should prompt them to do the necessary preplanning and make appropriate prearrangements to meet the NRC's physical protection requirements should a stop at a U.S. port become necessary.

When NRC officials are notified of or discover an impending transient shipment of a formula quantity, they will make preparations to inspect the carrier's physical protection system for the shipment while it is in port to ensure its adequacy or to take emergency measures if the required level of protection is not provided. The authority to make such inspections is provided for in 10 CFR Part 70.

The regulatory position of this guide describes the measures that may be employed in meeting the physical protection requirements for transient shipments. Sections 1 through 7 apply equally to scheduled and unscheduled transient shipments. Section 8 discusses the special considerations applicable to the physical protection requirements for unscheduled transient shipments and notes exceptions and alternative procedures for meeting such requirements. Sections 1 through 7 provide an outline acceptable to the NRC staff for use by the licensee in developing the required physical protection plan, although no specific format is required for such plans.

The bracketed references following each heading in the regulatory position denote the portions of the regulation applicable to the physical protection measures discussed under that heading.

4. PUBLIC DISCLOSURE AND CLASSIFICATION OF PLANS AND NOTICES

The NRC has determined that the details of physical protection plans and programs submitted to the Commission should be withheld from public disclosure by the NRC pursuant to Section 147 of the Atomic Energy Act of 1954, as amended. In addition, certain elements of such plans and programs and of the notices given the NRC in accordance with paragraph 70.20b(d) of 10 CFR Part 70 may be considered classified as Confidential National Security Information (CNSI) pursuant to 10 CFR Part 95 (published in the *Federal Register* on March 5, 1980, at 45 FR 14483). Any physical protection plans or programs prepared and maintained by carriers operating in the United States or their agents to satisfy the physical protection requirements of the NRC for transient shipments and the notifications given by such persons to the NRC in accordance with paragraph 70.20b(d) are considered classified and should be appropriately marked and handled accordingly (see § 95.39). However, similar types of information generated by persons outside the United States are not considered to be national security information if such information is not under the control of the United States Government. It is expected that the persons who generate such information will in their self-interest protect it from unauthorized access and public disclosure to the extent practicable. Detailed guidance regarding the elements of plans that are considered classified can be found in Appendix A to 10 CFR Part 95. Part 95 contains information on the proper handling and transmittal of classified information.

The following elements of the information required to be provided the NRC in the notification of a transient shipment are considered classified as CNSI:

1. Location of scheduled stops in U.S. territory.

2. Arrival and departure times for scheduled stops.

3. Details as to the type and quantity of special nuclear material contained in the shipment.

4. The numbers of guards who will protect the shipment.

5. Contingency plans for the response of security forces.

Most of this information is considered declassified when it becomes operational. More details on the conditions under which this information may be declassified may be found in Appendix A to 10 CFR Part 95.

Arrangements can be made on a case-by-case basis to coordinate the protection of safeguards-sensitive information regarding a transient shipment by contacting the Division of Safeguards, Office of Nuclear Material Safety and Safeguards, at the NRC headquarters in Washington, D.C. This contact can be made through the appropriate NRC Regional Office listed in Appendix A to 10 CFR Part 73.

C. REGULATORY POSITION

1. GENERAL CONSIDERATIONS

1.1 Purpose and Scope

The licensee physical protection plan is required to ensure that the licensee has done sufficient planning to physically protect transient shipments of formula quantities of strategic special nuclear material according to the requirements of the applicable regulations (i.e., § 70.20b, paragraphs 73.20(a) and (b), and § 73.25 of 10 CFR Parts 70 and 73). The plan should be available to the licensee's personnel for reference purposes when implementation becomes necessary.

A transient shipment is defined in paragraph 70.4(v) as a shipment of nuclear material originating and terminating in foreign countries, on a vessel or aircraft which stops at a U.S. port. The term "U.S. port" is intended to include all ports of entry that carriers would normally use in making such shipments but in unusual circumstances would also include the first landfall in U.S. jurisdiction, U.S. territories included, regardless of the transport mode or location. It is the carrier's responsibility to determine whether the amounts of SSNM being carried constitute a formula quantity, and if so, to provide the physical protection required by paragraph 70.20b(c) and the notification to NRC required by paragraph 70.20b(d).

The general license issued pursuant to § 70.20b for transient shipments of formula quantities of SSNM is effective from the time the shipment enters a U.S. port until the time the shipment exits that port. The planning and notification requirements obviously must be accomplished prior to the time the physical protection requirements of the general license become effective. Specific considerations related to meeting the physical protection requirements for unscheduled transient shipments of formula quantities of SSNM are presented in Section 8.

1.2 Contingency Plans [Paragraphs 73.25(d)(1)(ii) and (iii)]

Safeguards contingency plans for transient shipments are not required to be submitted for approval in advance of shipments as they are for domestic shipments of formula quantities of SSNM. Contingency plans for transient shipments should be an integral part of the physical protection plan provided by the licensee. A typical transient shipment is likely to remain in port for a limited time, from several hours to several days, considerably reducing the complexity of the contingency plans needed to satisfy the requirements of the regulation (compared with plans required for domestic road or multimode shipments that could involve several different local law enforcement jurisdictions and changing environments as the shipments move from one location to another along the planned routes). Contingency plans for domestic shipments are discussed in detail in Regulatory Guide 5.56, "Standard Format and Content of Safeguards Contingency Plans for Transportation."

Contingency plans for transient shipments are expected to include the following basic features and items of information:

1. Scope - A determination and identification of the types of safeguards-related incidents covered and not covered in the contingency plan. (For example, the plan may be designed to respond to armed attacks by small groups but not to armed insurrections.)

2. Trigger Events - Those events that will be used to signal the beginning or aggravation of a safeguards contingency according to how they are perceived initially by licensee personnel (e.g., discovery of a damaged SSNM container or broken seal, receipt of a written or telephoned threat against the shipment, discovery of attempted sabotage of the shipment).

3. Responses and Objectives - The actions that will be taken by licensee personnel in response to each of the trigger events and the objectives to be accomplished by each of the proposed actions. The persons within licensee management or the licensee security organization who will perform the response actions should also be specified.

4. Law Enforcement Assistance - A listing of the available local law enforcement agencies (LLEA) for the U.S. ports at which the shipment will stop and the methods arranged to communicate with them in the event their assistance is needed.

5. Other Considerations - Such items as constraints imposed upon security organization members (i.e., guards) by local and State laws, company policies and practices, and other factors, especially those relating to the use of deadly force.

1.3 Security Organization Training, Equipment, and Qualification [Paragraphs 73.25(d)(1)(i), (iv), and (v)]

Normally, seven armed personnel should be provided to protect a transient shipment stopped at a U.S. airport, while at least two armed individuals should be provided to protect a transient shipment on a vessel (not offloaded). This is consistent with the provisions of paragraphs 73.26(j)(3) and (l)(4).

Personnel selected to be members of the licensee's security organization entrusted with the physical protection of a transient shipment are required to be appropriately trained and qualified to perform all the tasks to which they are assigned. This includes being qualified and appropriately licensed by the local jurisdiction to use the weapons assigned them and being sufficiently fluent in English to ensure rapid and clear communications with the LLEA for purposes of requesting assistance from and coordinating with the LLEA response forces. Firearms, communications devices, and other equipment must be in good operating condition. To ensure that all security organization personnel and armed response personnel are properly trained and qualified, the licensee may arrange for the employment of such personnel in one of three ways:

1. Use of LLEA personnel. Such personnel may be presumed to be properly qualified with the weapons assigned to them while on official duty and to have the skills necessary to perform guard duties. LLEA personnel may be used while functioning in their official capacity, or they may be privately employed while off duty, depending on local regulations governing such employment and the willingness of the LLEA to provide temporary guard services.

2. Use of private guards provided by an organization licensed or approved by the NRC to provide physical protection of SSNM (such as for another NRC licensee).

3. Use of private guards who have been trained and qualified by the licensee, its U.S. agent, or other organization and have been determined by the licensee to be prepared to perform the tasks assigned them according to the licensee's written physical protection plan.

Foreign nationals who accompany a transient shipment into port as escorts for physical protection purposes may be considered to make up a portion of the guard force required for protection of the shipment while in the U.S. port. However, several considerations apply particularly in this case to ensure that such personnel are not unduly limited in the extent to which they are able to contribute effectively to the protection of the shipment. It should be ensured that language difficulties and lack of familiarity with local communications systems do not prevent their communicating rapidly and effectively with local law enforcement agencies or with other members of the guard force recruited locally. Efforts should be made to secure weapons permits in advance allowing them to legally carry weapons in the jurisdiction in which the port is located. In most local jurisdictions, these individuals may not legally carry their firearms off the plane or vessel without such permits. Inclusion of foreign nationals under a common command with other guards of local origin may hinder effective command and control of the guard force unless appropriate measures are taken to properly integrate the foreign nationals into the guard force.

Whether foreign nationals are utilized or not, the licensee should be prepared to demonstrate that persons employed to protect the shipment meet training and qualification requirements equivalent to the portions of Appendix B to 10 CFR Part 73 relevant to their assigned duties and that they can function effectively together to satisfy the general performance requirements and performance capabilities of §§ 73.20 and 73.25. Although there is no requirement under the general license to obtain advance approval from the NRC regarding the adequacy of the training and qualifications of guard force members, the licensee should be prepared to demonstrate such adequacy through appropriate documentation upon request by the NRC inspector assigned to the shipment.

1.4 Security Management [Paragraph 73.25(d)(1)(i)]

The plan should indicate the personnel (either by name or by position title) responsible for the physical protection of the transient shipment while the general license is in effect, including the chain of command, if applicable.

1.5 Testing and Maintenance Program [Paragraph 73.20(b)(3)]

Paragraph 73.20(b)(3) requires testing and maintenance of the physical protection system's components and procedures. This requirement covers all activities and devices on which the licensee's physical protection system depends to maintain shipment security. Its purpose is to ensure the continued availability of each component of the physical protection system. Since the physical protection system for transient shipments will normally be personnel oriented, the testing and maintenance activity for such systems will consist mainly of ensuring that procedures are understandable and workable by the personnel involved in implementing them. The licensee should ensure that all equipment, including communications devices and weapons, is in good working order. If equipment and armed personnel are provided the carrier by another organization, the licensee should obtain assurances from that organization that such equipment is in proper operating condition at the time these services are provided and the personnel provided are trained and qualified. The licensee should also make certain from time to time that the arrangements made and the procedures provided for in the plan are current and remain practicable and applicable to the conditions anticipated in future transient shipments.

1.6 Security Records [Paragraph 73.70(g)]

The types of records that must be kept are identified in paragraph 73.70(g). They include the names and addresses of persons authorized access to the SSNM while it is in port, documentation of security tours and inspections of the area containing the SSNM, and any other information obtained relating to the security of the shipment during the period of time the general license is in effect.

1.7 Reports to NRC [§ 73.71]

Section 73.71 requires that the NRC be made aware of any security-related incidents that occur during the period of the general license. The plan may specify procedures for reporting security incidents to the NRC when NRC inspectors are not present on the scene. When NRC inspectors are present, this requirement is satisfied by communicating such incidents directly to them.

1.8 Redundancy and Diversity [Paragraphs 73.20(b)(2) and 73.25(d)(4)]

The physical protection system is required to be designed with redundant and diverse measures. Redundancy means providing two or more measures that perform the same function. This would prevent failure of the entire system should there be a failure of one or more key system elements. Diversity means providing several types of measures that contribute to the performance of a particular security function. If these measures have a common purpose but different performance characteristics (e.g., sensitivities, failure modes, strengths, weaknesses), the system may be able to continue functioning adequately despite particular adverse operational conditions or an attempt to exploit a particular component's performance characteristics.

Since the physical protection system for a transient shipment is generally expected to be less hardware oriented than that for a U.S. domestic shipment, the means of ensuring redundancy in the system will be less involved. Licensees may focus their efforts at ensuring redundancy and diversity in the system by primarily addressing the communications functions and firearms capabilities. This may be done in several different ways.

Alternative communications capabilities should be provided so that more than one person can contact the LLEA to request assistance, and the communications equipment should be of different types in case one type becomes inoperable as a result of equipment failure, adverse broadcast conditions or jamming, or injury to one of the guards. Also, the means provided for alternative communications should be physically separated so that it would be unlikely that an adversary force would be able to destroy both capabilities for contacting the LLEA in a single attack. A single guard who is isolated from other guards should be equipped with a personal duress alarm that annunciates at a location occupied by other guards.

Guards should have shotguns and rifles available for use, as well as individual handguns, to ensure that they will be able to respond effectively to adversaries attacking from either short or long range.

1.9 Notification [Paragraph 70.20b(d)]

Carriers of transient shipments planning to make scheduled stops at U.S. ports are required to notify the NRC of their plans to do so prior to the arrival of the shipment. The notification should be sent by U.S. Mail to be received by the NRC at least 7 calendar days before the first scheduled stop in the United States. The notifications should be addressed to the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A to Part 73. This same office must be notified by telephone 7 calendar days in advance of the first scheduled stop at a U.S. port to inform the NRC that a shipping notice has been sent by mail and whether any changes have been made in the shipment's U.S. itinerary relative to the information contained in the mailed notification.

The licensee should take steps to ensure the confidentiality of the itinerary information and other information contained in the written notification since such information could be used to assist in planning a theft or diversion attempt. In the case of domestic licensees or others who generate such information under the jurisdiction of the United States Government, the notification may come under the requirements of 10 CFR Part 95, which require that it be handled according to specific procedures designed to protect it as Confidential National Security Information (CNSI).

The notification is required to include the following information:

1. Location of all scheduled stops in U.S. territory.

2. Arrival and departure times for all scheduled stops in U.S. territory.

3. A description of the transport vehicle (ship or aircraft) used for the transient shipment. This would include additional transport vehicles to be used if transshipment (transfer of the SSNM to another transport vehicle) is contemplated. The description should be given in sufficient detail to allow the NRC to unambiguously identify the transport vehicle for purposes of inspection when the shipment arrives in port.

4. A description of the nuclear materials in the shipment (elements, isotopes, enrichments, etc.).

5. The number and types of containers of SSNM.

6. The name and telephone number of the carrier's representative in the U.S. at each location in U.S. territory at which a scheduled stop will be made. If the carrier does not have a regular U.S. representative at a given U.S. port facility, he may name such a representative after making temporary arrangements with the representative for another carrier, or he may indicate that no U.S. representative has been designated.

7. A physical protection plan for implementing the requirements of paragraph 70.20b(c). The plan is required to include the use of armed personnel to protect the shipment during stops made at U.S. ports. This plan may be provided in one of two ways:

a. The plan may be included in full with other information required to be included in the 7-day notification, or

b. The carrier may refer the NRC to a physical security plan already submitted to the NRC by another licensee or by the same licensee for a previous shipment. The licensee may intend to implement this plan directly or arrange for another organization to use the plan to protect the transient shipment. When a previously submitted plan is to be used, the carrier should ensure that the plan is specific to each U.S. port at which a stop is to be made or should submit additional information to indicate how the plan is to be adapted to any other port at which a stop is to be made.

If U.S. Mail service is not directly available to the licensee, the licensee should use other means to ensure that the written notification will be received by the NRC at least 7 days prior to the first scheduled stop of the transient shipment within the United States.

The licensee is also required to place a followup call to the same NRC regional office to confirm that the required notification information has been received in accordance with the 7-day notification requirement.

2. SHIPMENT PLANNING AND CONTROL

2.1 Preplanning of Shipment Itineraries [Paragraph 73.25(b)(1)(i)]

It is recognized that, in the case of transient shipments, physical security objectives may not be the determining factor in the planning of the itinerary of the transport carrying the shipment. Also, the time may often be too short for carriers to make changes to accommodate such objectives and still meet their contractual commitments to other shippers. However, sufficient planning could be done in advance to ensure that all NRC physical protection requirements can be met when a transient shipment is planned.

Carrier's agents at U.S. ports should be informed of the NRC requirements so that they can make the necessary advance generic arrangements for the LLEA and private guard organizations to be available as needed. These arrangements and the plan for physical protection could be used by more than one carrier in case an agent represents numerous carriers.

Physical protection plans should be made as uncomplicated as possible to accommodate the necessity for using guard personnel who may have little familiarity with special procedures for protecting SSNM. This can be done by prohibiting offloading of the SSNM from the transport unless absolutely necessary, arranging to isolate the transport or shipment as much as possible from other transports, vehicles, and personnel (e.g., parking an aircraft at an isolated location on the airfield away from the passenger and freight terminals), and taking steps to facilitate the timely performance of any functions (e.g., repairs) that necessitated the stopover (to minimize the time spent in port).

An important part of the planning process is the arrangement made with the LLEA. Policies of these agencies differ with regard to the degree of involvement to which they are willing to commit themselves in the event of a transient shipment. The extent of potential LLEA involvement should be determined in advance, and the physical protection system designed to ensure that an adequate level of protection is provided. Where standing arrangements are in effect, previous arrangements with the LLEA should be reconfirmed just prior to a planned shipment's arrival to take account of any intervening changes in circumstances at a given port facility.

As part of the preplanning for transient shipments, a diagram of the important features of particular port facilities may be provided in the physical protection plan to facilitate implementation of the plan by the carrier's personnel or others.

3. DETECTION AND DELAY OF UNAUTHORIZED ACCESS OR MATERIALS INTRODUCTION BY STEALTH OR FORCE*

3.1 Establishment of Controlled Access Areas** [Paragraph 73.25(b)(2)]

Paragraph 73.25(b)(2) requires that controlled access areas be established surrounding the SSNM or its transport to isolate the SSNM and decrease the number of persons, materials, equipment, and vehicles allowed to come in contact with the transport or the SSNM.

Controlled access areas must have some means of demarcating the restricted area's boundaries that is clear to both authorized and unauthorized personnel.

There must be some way of controlling access to the area at all times to ensure that unauthorized persons are not admitted. Aircraft and seagoing vessels that enter U.S. port facilities need not be protected while they are in motion if it is determined that the SSNM on board is not accessible to unauthorized personnel during such motion. Thus, in most instances, armed response personnel will be required to protect the SSNM only from the moment the transport comes to rest within the port until it starts on its way out of the port (see Section 8 regarding unscheduled transient shipments). This greatly simplifies the physical protection system for transient shipments that use U.S. ports in comparison with the protection for domestic shipments (i.e., those that originate or terminate within United States territory). The physical protection plan should recognize, however, that the cargo compartment containing the SSNM, or the SSNM itself, should be placed under immediate surveillance as soon as the transport comes to rest in port to ensure that the SSNM remains inaccessible to unauthorized personnel. Airport ground crews, warehousemen, dockworkers, and other personnel should not be permitted to approach the transport or its cargo compartment unless surveillance is provided in accordance with § 73.25.

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*"Stealth" means methods used to attempt to gain unauthorized access, introduce unauthorized materials, or remove SSNM where the fact of such attempt is concealed or an attempt is made to conceal it. "Force" means violent methods used by an adversary to attempt to steal SSNM or sabotage a nuclear facility, or violent methods used by response personnel to protect against such adversary actions.

**"Controlled access area" means any temporarily or permanently established clearly demarcated area access to which is controlled and that affords isolation of the material, equipment, or persons within it.

The plan should describe the approximate dimensions of the controlled access area that would be established relative to the transport of SSNM and the means that would be used for its demarcation.

It should also indicate how attempts to penetrate the controlled access area without authorization will be detected, assessed, and communicated to ensure a response capable of preventing unauthorized removal of the SSNM. Procedures for accomplishing these tasks should be related to the response functions and communications capabilities described elsewhere in the plan. The plan should also detail the procedures that will be used to establish a controlled access area. Specific suggestions regarding measures to establish a controlled access area may be found in the reference system for U.S. domestic shipments [Paragraphs 73.26(f)(2), (i)(7), (j)(3), (k)(1), and (1)(3)].

3.2 Transport Features To Delay Access [Paragraph 73.25(c)(2)(i)]

The requirement for a transport to have features that delay access to the SSNM will usually be satisfied, for transient shipments, by such physical barriers as locked cargo compartments. To the extent that the transport lacks delay-causing features (for example, during periods when the cargo compartment is opened for loading or unloading other cargo), the physical protection system must provide compensating features (for example, stationing guards at the entrance) to ensure that the general performance requirements of § 73.20 are satisfied.

3.3 Access Detection for Transports [Paragraphs 73.25(c)(2)(ii) and (iii)]

The requirement for a capability to detect attempted penetrations of the transport containing the SSNM was intended to provide SSNM shipments with defense in depth—an added level of protection beyond that provided for by the controlled access area—which becomes especially important when many personnel must be allowed access into the controlled access area for servicing vehicles, handling other cargo, etc. In the case of a transient shipment, there would generally be very few persons authorized to have access to the SSNM or the cargo compartment in which it is contained. The same guards who administer the controlled access area procedures could be used to keep the SSNM or the transport under surveillance to detect unauthorized attempts to gain access provided these two requirements did not impose conflicting duties on a guard (e.g., having to focus attention on two different areas at the same time).

Physical protection requirements for shipments of formula quantities of SSNM other than transient shipments include requirements for the emplacement and periodic inspection of tamper-indicating devices on transports and cargo containers. For transient shipments, carriers are not responsible for the emplacement of seals or other devices but are responsible for ensuring that the seals or other tamper-indicating devices put in place by the shipper continue to function during the period the general license is in effect. Seals are not specifically required by the NRC in the case of transient shipments but they may be employed by the shipper in accordance with requirements of the International Atomic Energy Agency (IAEA) for shipments subject to IAEA safeguards. Paragraph 73.70(g) requires appropriate records to be kept of seal inspections during the time the transient shipment is in port.

4. DETECTION OF UNAUTHORIZED ACCESS OR MATERIALS INTRODUCTON BY DECEIT*

4.1 Access Authorizations [Paragraphs 73.25(b)(3)(i) and (c)(1)(i)]

Access authorizations are required to determine the time and conditions of access for persons who are authorized to be admitted to a controlled access area or for introduction of materials, vehicles, or equipment into such areas. Access authorizations are also required for entry into the transport. In the case of a transient shipment, there are expected to be few authorizations necessary. The number of individuals authorized access to the SSNM should be miminized. By limiting the number of authorized persons, the authorization subsystem may be kept relatively unsophisticated yet effective.

Access authorizations would normally be provided in written form, naming the individual to be granted access or the item to be introduced. It would also detail the criteria for entry (e.g., time, place, circumstances) and specify the reasons for which access is granted (e.g., to perform service on the transport, to load or unload other cargo). Written authorizations may be obviated by implementing an escort procedure. Under this procedure, all persons requiring temporary access would be escorted by an armed guard during such access to ensure that only authorized activities are being performed. Section 73.70 requires that written records be kept to document each occasion on which temporary access is permitted.

The physical protection plan may detail the procedures to be used by guards to determine which persons or materials are authorized access to (1) a controlled access area or (2) the transport or the SSNM.

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*"Deceit" means methods used to attempt to gain unauthorized access, introduce unauthorized materials, or remove SSNM, where the attempt involves falsification to present the appearance of authorized access.

4.2 Access Control at Entry Control Points [Paragraphs 73.25(b)(3)(ii) and (c)(1)(ii)]

Access control procedures are required to be implemented to ensure that only authorized individuals are admitted to controlled access areas or given access to the transport or the SSNM. These procedures involve three distinct subfunctions: (1) identification, (2) verification of identification, and (3) assessment against authorizations. Where few persons or materials are expected to be allowed access, as in the case of most transient shipments, these subfunctions can be performed quite simply without resort to some of the more sophisticated access control hardware and procedures used at fixed-site facilities or for domestic road shipments.

The main problem arising in providing physical protection for a transient shipment will be to allow positive identification of the LLEA or other guard personnel who are actively involved in the implementation of the carrier's physical protection plan. The carrier's agent may also have to be positively identified. The plan should detail the means that will be used to identify these persons before the carrier permits them access to the transport or the SSNM. The carrier should be capable of immediately communicating to the LLEA information concerning persons presenting themselves as contract guards, LLEA personnel, or other members of the security organization who are discovered to be impostors.

Once the composition of the security organization is confirmed, these persons will assume the responsibility for further implementation of the physical protection system according to the licensee's physical protection plan.

The means used to positively identify the members of the security organization who are to meet the shipment at the time it arrives in a U.S. port must be designed to limit the opportunity for successful use of false credentials or other deceitful actions. This would apply equally to other persons who may be authorized access to controlled access areas or to the SSNM.

5. PREVENTION OF UNAUTHORIZED REMOVAL OF SSNM FROM TRANSPORTS BY DECEIT

5.1 Authorization for Removal of SSNM from Transports [Paragraph 73.25(c)(3)(i)]

Authorizations for removal of SSNM from a transport would follow the same pattern established for access authorizations. For transient shipments, removal of SSNM while in U.S. ports will normally not be necessary. However, if unscheduled removal of the SSNM from the transport becomes necessary as a result of some unusual circumstance, removal authorizations would be determined on a contingent basis. The removal would be carried out under the direction of the carrier (or the person designated to assume responsibility for shipment) according to procedures detailed in the contingency plan. Removal procedures should be designed to ensure that no imminent or apparent threat exists to the safety of the shipment before the SSNM is removed to a more vulnerable situation outside the transport. Additional guidance regarding acceptable procedures for removal of SSNM from the transport may be obtained from Regulatory Guide 5.57, "Shipping and Receiving Control of Special Nuclear Material."

5.2 SSNM Removal Controls [Paragraphs 73.25(c)(3)(ii) and (iii)]

Removal controls are procedures followed in removing SSNM from the transport in which it has been contained. They are required both for routine (planned) and emergency situations and may include such activities as verification of the identities of persons performing the removal operation and persons to whom custody of the SSNM is to be transferred. The identity of the SSNM being removed and integrity of the containers and any seals are also items to be verified. These procedures act as a filtering process to ensure that the proper conditions exist and appropriate personnel have been positively identified prior to the removal. Response measures to ensure that deceitful attempts at unauthorized removal of SSNM will be detected and communicated to responsible persons are intertwined with removal controls and may be described in the main body of the plan or referred to a more detailed description in the contingency plan.

6. DETECTION OF UNAUTHORIZED REMOVAL OF SSNM FROM TRANSPORTS BY STEALTH OR FORCE

6.1 Transport Features to Delay Removal [Paragraph 73.25(c)(4)(i)]

Transport features to delay unauthorized removal of SSNM from the transport by stealth or force should be considered an integral part of the physical protection system. When such features are designed into the transport, the physical protection system may take credit for the amount of delay provided by them. To the extent that the transport has features that provide for only a slight delay capability, other components of the physical protection system must be strengthened to compensate for the lack of sufficient delay afforded by the transport. The balancing of these delay and other factors (e.g., response time, size of guard force) is a matter of judgment by the licensee and ultimately the NRC inspection staff. The general guidance is that these factors must be balanced in such a way that general performance requirements of § 73.20 can be satisfied.

Some transport features that delay access may also delay removal. Features that were not previously discussed as delaying access should be included in this part of the plan along with descriptions of those aspects of previously described features that help to delay removal as well. These features may include arrangements for securing the SSNM in the transport vehicle (e.g., securing heavy equipment necessary for removal of the SSNM, binding together the individual packages of SSNM so as to make a one-step removal cumbersome, and binding the SSNM containers to the structure of the transport). These features may or may not be present on board the transport vehicle for a transient shipment. In some cases, these features may be present for safety or other purposes rather than for physical protection purposes. To the extent that the physical protection system depends on such features to delay unauthorized removal, the licensee should describe which of these features are utilized on board the particular transport vehicle used for the subject transient shipment. If such features are not actually employed, the licensee should take action to employ them or take compensatory action to ensure satisfaction of the general performance requirements.

6.2 Detection of SSNM Removal Attempts [Paragraph 73.25(c)(4)(ii)]

Detection of SSNM removal attempts for transient shipments could be performed in most cases by the same personnel assigned to detect unauthorized access to the controlled access area, the transport, or the SSNM. The licensee should be careful to ensure that these duties, when assigned to particular guard personnel, are not in conflict with other duties assigned them.

7. TRANSMISSION OF DETECTION, ASSESSMENT, AND OTHER SECURITY-RELATED INFORMATION

Various requirements for communications capabilities are described in the regulations relating to detection and assessment; requests for assistance from response forces or the LLEA are described earlier in this guide. The communications capabilities described in this part of the plan would support the performance of these other physical protection functions.

7.1 Communications Among Guard Force Personnel [Paragraph 73.25(d)(2)(i)]

A continuous communications capability is required between members of the transient shipment's guard force. This capability is needed for routine purposes as well as for implementation of emergency procedures detailed in the contingency plan. Communications could be conducted using citizens band hand-held transceivers or other similar equipment where face-to-face unassisted voice communications are not practical. On board docked oceangoing vessels, the ship's hardwire communications system may be used, especially where metal shielding would not allow the use of transceivers. The communications function is an extremely important one with regard to the overall effectiveness of the physical protection system, so that its redundancy and diversity needs to be addressed. Transceivers capable of using more than one channel should be utilized to ensure that some form of communications with the LLEA is possible at all times in the event of a safeguards incident. Dividing the guard force into two or more different groups to ensure their survivability in case of a single attack has been suggested as one procedure to ensure that the communications function will be performed. (See Section C.1.8 of this guide.)

7.2 Communications Between Guard Force Commander and Security Control Center [Paragraph 73.25(d)(2)(ii)]

In the case of transient shipments, the requirement expressed in paragraph 73.25(d)(2)(ii) translates to the following: a continuous communications capability should be maintained between the guard force assigned to protect the transient shipment and a remotely located security control center manned by personnel employed by the licensee to monitor the status of the shipment while it is in port. This security control center could be located in the offices of the carrier's U.S. agent or at some other temporary location in the area of the port. The security control center should maintain knowledge of the status of the shipment at all times during the period the general license is in effect. This could be accomplished through an intermediary such as an airport control tower or the harbor master's office during times the transport is in motion within the port.

Communications between the guard force commander and the security control center need not be continuous, but the capability for immediate two-way communications by either the security control center or the guard force should exist while the shipment is in port.

7.3 Liaison with and Notification of Local Law Enforcement Authorities (LLEA) [Paragraphs 73.25(d)(2)(iii) and (d)(3)]

Both the armed guards for the transient shipment and the security control center personnel are required to possess the capability for direct communications with the LLEA to notify them of the need for assistance if necessary. The need for such communications is underscored by the basic philosophy of the licensee physical protection system. The guard force for the transient shipment need not be designed to defeat potential attackers in an aggressive mode, but only to protect the shipment and guard personnel from attack. Its primary objective should be to delay the adversary from completing any act of theft of SSNM or sabotage until the LLEA forces arrive. The system should be designed to interface closely with LLEA forces whose responsibility it is to enforce local and State laws regarding thefts and other criminal acts. The capability of the guard force to call LLEA forces into action when such assistance is needed is of great significance to the success of the physical protection system and deserves to be protected with an appropriate level of redundancy and diversity. Liaisons with LLEA personnel should be consummated in advance of the shipment or as soon as possible following arrival in port.

8. SPECIAL CONSIDERATIONS FOR UNSCHEDULED TRANSIENT SHIPMENTS

8.1 Purpose and Scope

The purpose of the physical protection system for unscheduled transient shipments does not differ from that for scheduled transient shipments. However, the scope of protection may differ owing to the unpredictability of the circumstances that would require the transport to make an unscheduled stop at a U.S. port facility. There are essentially two differences.

1. The randomness of stops made at U.S. ports would make them difficult for the adversary to predict so that, for a period of time following arrival in port, the shipment would have a degree of protection arising solely from the randomness of the event. As the time in port grows longer, the ability of the adversary to assemble or regroup his forces and transport them to the port from another location increases also. This will affect the timing of implementation of the physical protection system for the transient shipment.

2. Since the unpredictable factors of weather, equipment failures, or other unusual circumstances may result in the shipment arriving at a U.S. port at which the carrier neither has made previous arrangements for physical protection nor has a U.S. agent or representative, the physical protection system may have to be implemented by the carrier with little specific knowledge of the port. This will require a much greater dependence on the port's LLEA for cooperation in the early period following arrival in port.

8.2 Notification Requirements [Paragraph 70.20b(e)(1)]

For unscheduled transient shipments, it may be impossible for the licensee to notify the NRC 7 calendar days prior to the arrival of the transport in a U.S. port, as is required for scheduled transient shipments. However, the carrier is required to notify the NRC of its intent to bring a transient shipment of a formula quantity of SSNM into a U.S. port by telephone, radio, or other means immediately upon the carrier's decision to enter a U.S. port. The notification should contain the same types of information included in the 7-day notification required for scheduled transient shipments [as described in paragraph 70.20b(d)] except that some information regarding the name and address of the carrier's U.S.-based representative and the physical protection plan may be unavailable. The carrier may, in fact, not have a U.S.-based representative or agent at the port in question and may have little choice of which port to use, especially if the stop is made because of adverse weather conditions or equipment failure. In such situations, the carrier may choose to name a member of the crew who would assume immediate responsibility for the transient shipment's physical protection and make other arrangements after landing.

8.3 Implementation of Physical Protection Plans for Unscheduled Transient Shipments [Paragraph 70.20b(e)(2)]

Physical protection plans may not need to be implemented immediately upon arrival of a transient shipment at a U.S. port. However, the time that would be allowed to elapse before physical protection plans must be implemented would depend on a number of factors such as the amount of time during which the shipment is expected to remain in port, whether it will be necessary to transfer the SSNM to another transport, or whether there has been any civil unrest (e.g., protest demonstrations) or a recent natural disaster that may appear to pose a threat to the safety of the shipment (e.g., increased risk from mob actions). Another factor is the extent to which there is public knowledge of the transient shipment entering the port and how much advance knowledge could have been obtained by potential adversaries. Generally, physical protection measures should be implemented within two hours after arrival at the port. NRC inspectors or headquarters personnel would make the final determination based on what is reasonable in the light of local conditions and other circumstances.

In the event physical protection of an unscheduled transient shipment becomes necessary, the licensee will be required to arrange for protection by armed personnel. These may be armed guards provided by a commercial guard service or personnel provided by the LLEA. Whether LLEA personnel will be available will depend on the operating policies of the LLEA at the particular port. If the port has its own security force of armed personnel, it is likely that their services could be obtained, either temporarily until other arrangements can be made, or for the duration of the stop.

8.4 Physical Protection Plans [Paragraphs 70.20b(d)(7) and (e)(1)]

In the event a carrier finds it necessary to bring a transient shipment into a U.S. port with minimal preparation, carriers are required to indicate immediately after the decision to enter a U.S. port the means they will use to ensure the physical protection of the shipment. Plans for providing this physical protection may become available to NRC inspectors in a number of different ways:

1. Carriers may prepare and have on board their own plans in accordance with the regulations and the guidance contained herein. Carriers transporting SSNM of formula quantities with itineraries bringing them within range of U.S. ports might anticipate use of these ports for emergency stops and plan ahead to meet such contingencies.

2. Carriers may have on board, or on file with their agents at a U.S. port or ports, physical protection plans prepared by themselves or their U.S. agents that (a) may be adapted specifically to particular ports at which they may make emergency stops or (b) may be generically designed to be adapted to any port as circumstances require. The latter alternative will leave the carrier with the necessity for making final arrangements for physical protection as the need arises for any given port situation.

3. Carriers who have done no advance planning for physical protection can still comply with the regulation by preparing ad hoc plans while approaching port, if time allows, or shortly after entering the port. They may prepare their own plans in response to the guidance contained in this guide, or they may attempt to obtain the services of a U.S.-based agent who may be more familiar with the NRC physical protection requirements for transient shipments.

NRC inspectors may require the licensee to take certain actions in order to protect the SSNM if they determine that the protection provided by the licensee is inadequate.

VALUE/IMPACT STATEMENT

A separate value/impact analysis has not been prepared for this regulatory guide. The guide was developed to provide guidance to persons subject to physical protection requirements for transient shipments contained in 10 CFR Parts 70 and 73. These requirements were promulgated by amendments to NRC regulations published in the *Federal Register* on February 13, 1981 (46 FR 12193). A value/impact analysis was prepared for the amendments originally proposed for the physical protection of transient shipments on January 8, 1980 (45 FR 1625), a copy of which was placed in the Public Document Room at that time. This analysis is also appropriate to the final amendments and to this regulatory guide since only minor changes were made in the proposed amendments when the final rule was published.

The major conclusions of the value/impact analysis were that the required physical protection could be provided at reasonable cost and minimal impact to the parties concerned, that the costs of providing such protection are essentially independent of the technical and procedural alternatives considered, and that the overall level of impacts, including those to the NRC, other government organizations, industry, workers, and the public, and also the impact on international relations, will be minimal because of the small number of potential licensees.